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SECONDARY BATTERIES AT THE SOCIETY OF ARTS.

MR. W. H. PREECE, F.R.S., read a paper entitled "Secondary Batteries" before the Society of Arts, on the 1st of May. To reproduce the paper *in extenso* would almost amount to a reprint of the trade circulars of several companies who have issued excellent catalogues, which, so far as their own wares are concerned, teem with useful information. Any one not a member of the Council would scarcely have been permitted to present a paper to the Society of Arts in such a form as this, and Mr. Preece appears to have made the utmost use of his privileges by compiling what, on the face of it, looks like a glaring trade advertisement, without even the usual admixture of new scientific data. This fact seemed to us all the more inexplicable when the author remarked that he had probably had more experience with secondary batteries than any other man amongst his audience. There were at least a dozen electricians in that room with a record of from five to ten years' practical experience in their wholesale manufacture and use, and we noticed a sad, yet good natured smile illumine some faces as this bold assertion fell from Mr. Preece's lips.

In referring a second time to the actual catalogues to which we have alluded, we find the language and style employed therein exceedingly modest when compared with the utterances of Mr. W. H. Preece, whose enthusiasm seemed to have no bounds on the evening in question, and we are tempted to attribute his exaggerated and highly-coloured eulogium to other than the love of pure science. If we may regard Mr. Preece, for the present purpose, as the mouthpiece of the largest manufacturers of accumulators in this country, then we ought to tender our best congratulations to those firms, and especially to the users of these convenient adjuncts to electric lighting, provided the figures of Mr. Preece can be guaranteed. Thus, in speaking on the maintenance of secondary batteries, the author asserts that "the negative plates should last for ten years," and "if the maximum rate of the output of about 4 ampères per plate be adhered to, the duration of the positive plate may be taken to be three years." According to the E.P.S. price lists, a cell of 330 ampère-hours capacity, with glass receptacle, costs three pounds. The renewal of a complete positive plate section, containing seven plates, is 12s. 3d., but the price of the negative section is not given; however, separate plates can be obtained for 1s. 6d. each, and there being eight plates in a section, we may assume this item to be 13s. 9d., including terminals. The glass box cannot wear out, but accidents may happen, so we credit it as breaking every ten years. The companies charge 10s. per glass box, so we reckon this at 1s. per annum. Thus the annual renewal of positive plates would be 4s. 1d., that of the negatives 1s. 4½d., and the glass vessel 1s., giving a total of 6s. 5½d., or nearly 10¾ per cent. per annum on the gross list price of the battery. In his reply to the discussion, however, Mr. Preece said that he could not recommend any one to estimate the depreciation at less than 15 per cent. per annum. Mr. Crompton "did not consider the depreciation, under proper management, was greater than that of ordinary machinery." Now, all this is very vague, and we should like to know positively whether the makers are really prepared to guarantee the life of the plates for three years and 10 years respectively, if the maximum current of four ampères per positive plate is adhered to. Extracts, if not whole copies, of this paper, will doubtless be sent to shareholders of the companies interested in the big combination about to be effected, and these might with advantage include exact figures in support of the sentences so hopefully expressed at the meeting.

Mr. Preece tried very hard to bring forward something original in order to make his paper interesting, and at the same time to back up his preconceived notion that secondary batteries have reached the highest point of perfection. Thus he tells us that "the character and the quality of the electrolyte used in

secondary batteries has scarcely received the attention it deserves. Hitherto scarcely anything but a solution of sulphuric acid has been employed." Then he went on to describe the suggestion of Mr. Barber-Starkey, that of adding soda to the electrolyte. Nearly every technical paper took account of this two or three years ago, and probably every man seriously engaged in the subject of storage batteries has tried it with more or less success. Mr. Preece further said that a solution in the proportion of five pints of sulphuric acid with one pint of sulphate of sodium in 19 pints of water gave the best results. "Six months experience with two sets of cells has confirmed the result that immense benefit is to be derived from the sulphate of sodium solution. There has been no evidence of buckling, there has been little or no scaling. The bottom of the cells are nearly as clean as when they were first charged, while the bottom of those charged with the sulphuric acid solution have the usual accumulation of oxides of lead. Two cells were also, and at the same time, charged, the one with sulphuric acid, and the other with the sodium solution, and very careful tests of these two cells show that the addition of soda does not impair either the E.M.F. or the internal resistance, nor does it diminish the output of the cells."

These statements evoked an interesting discussion from several speakers who have experimented with various solutions.

Mr. Crompton stated that the use of soda to prevent sulphating was specified some years ago by M. Monnier as probably the best cure. He did not use carbonate of soda, which was changed into sulphate of sodium in the presence of sulphuric acid, but advocated the addition of magnesia or soda; Mr. Crompton considers sulphate of sodium as the best, but he could not agree that it had no effect on the E.M.F. or the condition of the cells. Sir Frederick Abel said that he did not think that the action was difficult to explain. It appeared probable that a double salt of lead and sodium was formed, which was soluble, whereas the sulphate of lead was comparatively insoluble. Sir Frederick agreed, as Mr. Crompton suggested, that the action of the cell would not be quite the same if the soda salt was added in considerably quantity. Mr. Parker mentioned that he used potash and soda at a very early period, but for some reason it had not been adopted in regular practice. It would have been interesting had he stated the reason. Mr. King did not quite appreciate the addition of soda which he thought had generally been tried with batteries which had gone wrong, with the result that the pellets of paste had all come out.

Mr. Swinburne pointed out that, on theoretical grounds, sulphate of soda would have the effect of reducing the sulphate of lead which was soluble in it. The same effect might be produced to some extent by using stronger acid. If a cell is left discharged, a lot of sulphate is produced; but it was in a different form, as it merely arose from the soda sulphate in contact with the plate. The ordinarily precipitated sulphate could easily be reduced by mixing it with a small quantity of one of the oxides, but probably the soda was the simplest method of preventing it.

Mr. Reckenzaun took up the subject of "buckling" of plates which Mr. Preece touched upon, but of which no clear explanation had yet been given. The speaker's opinion was that buckling was due, firstly, to the ordinary expansion of the active material when peroxidised. If the oxide were confined within the narrow meshes of a perforated plate, either the grid must expand, or the oxide must come out; he found that the softer the retaining material was the less deterioration it suffered from this cause. When an alloy of lead and antimony was used he found that unless the grid were made very strong it would split, and if it did not, the oxide would go. The natural expansion of lead by oxidation was about 14 per cent., if every atom of the lead were active; but in practice not more than one atom in 10 was really active. This expansion was one cause of buckling, but a more important cause was the sulphating, and excessive sulphating generally occurred when the cells were left to stand idle after being wholly or partially discharged. The sulphuric acid had then time to combine with the lead and form sulphate in all the crevices, and thus the plate was expanded inordinately, and caused the buckling. The main thing was never to discharge a battery below a certain point, and then not to let it stand idle. He had made a number of experiments to ascertain whether the form of the plate had any influence upon irregular expansion, and he found that if the proportion between the active material and the retaining material, which was ordinary pig-lead, was well chosen, the plates did not buckle at all, no matter how badly they were used. His plates were constructed very differently to any of those shown at the Society, and he had obtained excellent results with them during $3\frac{1}{2}$ years' continuous use.

Mr. Reckenzaun took Mr. Preece to task on the question of the efficiency of a storage battery which was stated in one part of the paper to be 95 to 98 per cent. He could not accept that, understanding by efficiency the ratio between work expended in charging and that returned in the circuit. In charging the battery an average of $2\frac{1}{4}$ volts E.M.F. was required to send the current through at a practical rate, and in discharging not more than two volts can be obtained on an average, so that if the efficiency in ampère-hours were 100 per per cent., the efficiency in energy could not be more than about 88 per cent.

Mr. Preece replied that this was a fallacy which he was rather surprised to hear propounded by Mr. Reckenzaun, though he once entertained it himself. Here Mr. Preece got into a perfect muddle by trying to explain "that it was quite true that the E.M.F. was higher during charging than when discharging, but the *current* given out was very different. That depended on the E.M.F. and the resistance, and the resistance during charging was greater than during discharging in the ratio of 4 to 1. If in one instance the E.M.F. was greater, and in the other the current was less, the result was that the product of the two was precisely the same, and it was quite possible to take out of a battery just as much energy as you put in, and, as a matter of fact, he had taken out 98 per cent." Mr. Preece must have forgotten that the resistance of a

secondary battery varies continually, it is least when the cell is fully charged, and greatest when discharged, it varies just as much during charging as when discharging, and its counter E.M.F. is greatest when the internal resistance is smallest.

Mr. Drake spoke of the installation at the Prudential Insurance Offices, where they had 3,500 lamps of 16 candle-power. The batteries were there used, as they ought to be, in large installations as regulators, and for the supply of light when only a small number of lamps were required. When worked in that way there was very little depreciation, and the interest on the first cost was more than covered by the long life of the lamps. This installation had now been in use over three years, and the average life of the lamps was over 2,000 hours, while many had run as much as 4,500 hours. He agreed with Mr. Parker that secondary batteries used as regulators at central stations would put the system on a very different basis to the present, in which the battery was charged by the dynamo, which was then cut off and the current taken out, with the full loss of a double conversion of energy.

Mr. King said that a secondary battery ought to be used in the same manner as a gas company used a gasometer, as a reservoir, and as a means by which a constant small additional supply of electricity might be available during the hours of maximum pressure. Under such circumstances there was no doubt that a profitable return could be obtained for the capital employed, large though it might appear, and the installation, as a whole, was worked most effectively because the engines were always working at their maximum power. He thought that storage batteries might give an efficiency of 83 to 84 per cent., but he could not see how they could go beyond.

Mr. Crompton strongly advocated the use of accumulators for crowded buildings to save loss of life, as it prevented that great feeling of anxiety which attached to the engineers in charge of any central station under the direct supply system, who knew that at any moment the bursting of a steam pipe, or anything of the kind, would plunge the whole district into darkness. The very worst accumulator even gave a certainty that if anything happened the light would only die out gradually; and a difference between that and a sudden extinction was so great that he need only refer to it.

Thus ended an evening which, on the whole, was at least to electrical men a disappointment, but Mr. Preece was nevertheless the means of raising a discussion which brought to light several practical ideas and experiences which had not hitherto been expounded.

THE phonograph was presented to the Société Internationale des Electriciens at their last monthly meeting which took place on the 1st of May. M. Cadoux lectured upon the subject and his son acted as demonstrator. Much amusement was caused by the rendering of a speech addressed to the instrument before the audience, and intermixed with whistling, halloing and animal cries. The sounds emitted through the trumpet are essentially nasal, but the whistling portion was particularly clear and audible. An orchestral piece of music made a great impression, and the rendering of "La Marseillaise" did not fail to elicit a tremendous roar of applause from the enthusiastic audience. The President of the Société spoke into the instrument, reading from notes a short speech addressed to the inventor, thanking him in the name of the Société and complimenting him upon his wonderful invention; the speech terminated by an allusion to the United States and French Centenaries, both being just celebrated at the present moment. Mr. J. Hammer, the originator of the recent telephonographic experiments between New York and Philadelphia, was introduced to the audience. These experiments were published in the REVIEW for March 8th last.

COLONEL GOURAUD, with his Edison phonograph, writes a correspondent of the *Independance Belge*, was all last week the Paris lion. He showed the astonishing instrument, not only at the Presidency of the Republic where M. Sadi Carnot was much interested in the mechanical details, but also at the *Figaro* office and several clubs, notably at the Union, the Paris rendezvous of foreign diplomats. I have been enabled to see a phonograph of the new model and I have heard some entire sentences of a month old and which had been spoken into the apparatus in England. These came to me as distinctly as though the voice had spoken in my ear. The "Marseillaise" also phonographed at London and played on a piano and cornet did not less astonish me. Lastly, a singer near me having sung a couplet of a romance, the phonograph scrupulously rendered the couplet and a whistle which had been contributed by a bystander. All this seems magic, does it not? Colonel Gouraud states that the human voice may be preserved as fresh as possible for ten years. In this connection, imagine for example, an heir, Mr. ———, peacefully enjoying a fortune left him by a written will. Among the things left him is the phonograph of the defunct, and one day, when the heir has everybody at his house to see him, in order to amuse the company he gives a hearing to all the voices contained in the apparatus. What would be his astonishment to hear the dead man's voice pronounce in a most intelligible manner the simple words: "Struck with paralysis at the moment of appearing before my maker, I confide to the phonograph my formal intention of revoking my former will, and I appoint Mr. A. my heir." This would indeed be a coup de theâtre, especially if Mr. A. were present. Joking apart, however, it is simply astonishing the enormous amount of attention and space devoted by all classes of French newspapers to this latest Parisian novelty.

THE Press and the electric lighting companies of New York are up in arms against the Mayor! Whatever is, is wrong! Not long back the New Yorkers were complaining about the unsightly and irregular appearance of the overhead wires throughout their city, the late Mayor being strongly blamed for not taking action to compel the electric lighting companies to remove the aerial conductors, and put them in proper conduits underground. Hopes were expressed that when his tenure of office was up, his successor would deal with the matter in an effective and rapid manner, for had he not promised in the event of the companies not carrying out the alterations required by the notices, he

would enforce the provisions of the State Law, and summarily remove all wires and poles which remained in contempt. Mayor Grant has fulfilled his promise, has acted with the utmost vigour, has chopped down poles with no more feelings of remorse than a back-woodsman does when he makes his clearing in the midst of the primæval forest, and the mains must either go underground or the public without the light. *Hinc illae lachrymae*! One paper regrets the removal of the familiar wires and poles, picturesque and rustic, not to say crooked, and is sorry that historic (*sic*) relics are being ruthlessly destroyed. They had been looked upon as something permanent, much less liable to blow down, than the buried substitutes to be blown up, and the iconoclastic mayor has given the electric companies the *rôle* of the persecuted, and has thereby strengthened their cause and their hold upon the public. The accidents that have occurred during the removal of the poles and the darkness that has resulted on the principal streets, has made knickerbockers feel that they can still continue their boast of being first, but this time in "jumping from the frying pan into the fire." In some parts of the City the poles used are metallic ones, and the overhead service is constructed both substantially and with due regard to outward appearance; if these are to be taken down it would be amusing to see the wood-choppers attacking an iron pole of improved construction, and it is considered a pity that some one cannot call a halt to the hasty and ill-advised crusade against a legitimate business, and for which the public will, sooner or later, hold the Mayor responsible for the damages inflicted upon the business interests of the city.

WE think it hardly fair to blame him for energetically taking in hand that which he was pledged to undertake, and it would seem that the right was on his side, and he was therefore justified in doing as he has done, still it is not always a question of what an official has a right to do, but what is it right for an official to do? and on this plea he would have been better advised to wait until the Washington centennial celebration had passed, and not till then to have adopted drastic measures. We are not actually aware in what state of light or darkness the streets were in during the festival last week, but the predictions of the press were dismal in the extreme. Hundreds of thousands of strangers would flood the city, and the business of the city was to protect them and give them every safeguard, that it was absurd to talk of lighting them by gas, whose flickering jets only serve to make darkness visible, that on those nights of celebration pickpockets would abound, while every lamp would be worth a policeman. The woodchoppers employed to cut down the poles do not seem to have had the skill in the use of the axe that the former inhabitants of New York State possessed; the latter, according to repute and records, were accustomed to wager that a tree of goodly girth and height should fall exactly where required, which spot they would indicate by placing a hat over it, success would then attend their efforts in at least nine cases out of ten. The men employed removing the poles have not done their work successfully, and two fatal accidents have occurred where workmen have been dragged down by the falling poles and crushed on the pavement below. These workmen, could they have spoken, might have used the words of Horace, *Ille et nefasto te posuit die*, &c., with even more appropriateness than their author, who was more frightened than hurt by the occurrence immortalised therein.

IT will be good news to many nervous travellers who are compelled to put up at hotels where gas is still used as the general illuminant, to know that they should no longer have their lives or property placed in jeopardy through an escape of gas caused by the primitive method adopted by some persons in blowing out the light in place of turning off the tap. An electrical invention has been announced from America which will ring a bell in the hotel office and at the same time register the number of the room in the event of a gas light being either wilfully or accidentally blown out. However useful this invention may be in saving the consumption of gas, and of preventing possible danger of suffocation to the occupier of the room, let us hope it will not be long before some ingenious denizen of the Great Republic will devise an electrical appliance to facilitate the transference of the weary traveller from a warm bed to the early train which he has boldly overnight declared his intention of catching, but when the morning—dark and dreary may be—comes, and the boots cries "Up! up!" he answers "No, no." "Yes! yes! get up" "Can't." "Rise! rise!" Then misery! The above device must be capable of awakening the tired visitor, but prior to doing this it must perform several little operations, such as shaving him, putting on his boots, &c., so that, when at length he is aroused from his slumber, he shall be in the best of humours with himself, will have plenty of time to take the cup of hot coffee awaiting him by his bedside and to saunter off gaily to his train. The bounteous favours of fortune in this world will attend the lucky inventor and his name will be blessed and revered for countless æons to come.

THE degree of success obtained by Dr. J. Inglis Parsons in the treatment of cancer by means of electrical appliances leads us to hope that many diseases may eventually be cured, or be prevented from extending, and this without destruction to the normal tissues of the body, accompanied with the knowledge, in case of a recurrence of the malady, that its progress can be stopped and many a valuable life be prolonged.

THE following story is confirmatory of the advantage of certain electrical remedies:—A year or two ago, on a certain day, a man might have been seen slowly and painfully wending his way towards a well-known hospital in the North of London; the man was minus one boot, which was replaced by an assortment of bandages, and his progression was assisted by the use of a couple of thick sticks, but, notwithstanding the support these latter afforded, he was compelled to make frequent stoppages, for the sole purpose, apparently, of giving vent to fervent and oft-repeated ejaculations of a character, if one might judge by the contortions of the man's countenance and from the nature of several words that sounded in the ears of the passers-by, not benedictory nor expressed in that tone of resignation one would expect from a martyr to the common complaint y-clept the gout. The would-be patient, although aware, from past experience, of the futility of anticipating permanent benefit from the treatment at the hospital, was going there hoping to obtain some present relief from the grievous arthritic agony he was enduring. Arrived at the hospital, and not seeing the doctor who usually attended to his case, he was brought before one of the senior physicians, who has the reputation of being extremely clever in his profession, but who holds views in regard to medical therapeutics somewhat pronounced,

and expresses the same with so much vigour and in such forcible language that one unacquainted with the genuineness of the man or the excitability with which he enunciates his doctrines would be pardoned if he set them down as somewhat bordering on eccentricity. "Do you mind pain?" said the doctor, "or if you do, I suppose by the look of you you are used to it, and a little more will not hurt you much and may cure you. Have you tried electricity?"—"No." "Very well, then; come along, and we will see what we can do for you. But you must allow me to apply it in any manner I please, and I am perfectly confident of seeing you walk out of the hospital with a firm and elastic tread, as though gout had never been your boon companion."

THE treatment commenced; our doctor, unfortunately not being *au fait* in the measurement of electrical currents, was unable to note, for the future benefit of science, the exact strength of the currents he used, or the pathological results from the several forms in which they were administered. In endeavouring to hit on the most useful form and strength of current he, so to speak, ran through the whole electrical pharmacopœia, at one time sending into the tortured limb a small and almost inappreciable continuous current, then a sudden shock from a powerful one, and again utilising an induction coil to produce the most powerful but involuntary contortions of the diseased limb. After an extra vigorous twister the doctor would say, "How does that feel?"—"Oh snakes! Whew?" "Put your foot to the ground."—"Can't." An extra twist. "Now down with your foot," followed with another twister to occupy the patient's attention and to divert his thoughts at the moment of placing his foot in contact with the floor. After an hour or so of this treatment the man was able to walk about the room, and finally was able to depart with his sticks tucked under his arm, and to strut off with an air of jauntiness that had long been absent from his gait, not forgetting before leaving to call down on the doctor's head all the blessing of the powers above, from the holy Moses to the last canonised saint.

THE man was not seen again at the hospital for perhaps 18 months, when once more he turned up supported on two sticks and with a bandaged foot, also undergoing racking pain. He wished to see the doctor who had cured him before, and whose treatment had staved off the return of his complaint for such an unusual length of time. The physician was fortunately in attendance, and soon made preparations to renew his former method of electrical cure, remarking to one of his colleagues who was present that he should see the patient leave the hospital in the perfect use of his limbs and all his pain dispersed. "He would eat his hat if he did," replied the second practitioner. Whereupon the gouty man declared with emphasis that he would be darned if he would not eat his own hat and the doctor's too if the cure was not effected. The man walked out cured, and, we believe, has never had occasion to return to the hospital since.

IT will soon be possible, says the *Morning Post*, to form some estimate of the losses incurred in connection with the French "gamble" in copper which terminated so disastrously for all concerned in it a few weeks ago. Judging from the report of the official liquidator of the Société des Métaux, presented to the bondholders on Saturday last, the adverse balance is likely to prove even heavier than people generally anticipated. This corporation was interested in the speculation at the time when it was obliged to suspend payment to the extent, it now appears, of about 130,000 tons of the metal, valued at 135,000,000 francs, or, roughly speaking, something over £5,000,000. The result of the operations of the Paris Society shows the total losses sustained up to the present to be over 120,000,000 francs, or nearly the entire estimated value of the copper they contrived to corner. For the further liabilities of the company in respect of the contracts it will be unable to execute, and for the depreciation in the value of the metal it holds, it is well within the mark to allow a further sum of £1,500,000 at the lowest, thus bringing up the total losses incurred by the Société des Metaux on its speculative transactions to between £6,000,000 and £7,000,000.

WE wonder how many times more the statement will be made that a building which is furnished with a lightning rod affords protection against lightning over an area the diameter of which is twice the length of the rod. As we have again and again pointed out, this law, which was promulgated at the First Lightning Rod Conference in France, several years ago, was at the Second Conference unreservedly withdrawn as having no foundation in fact.

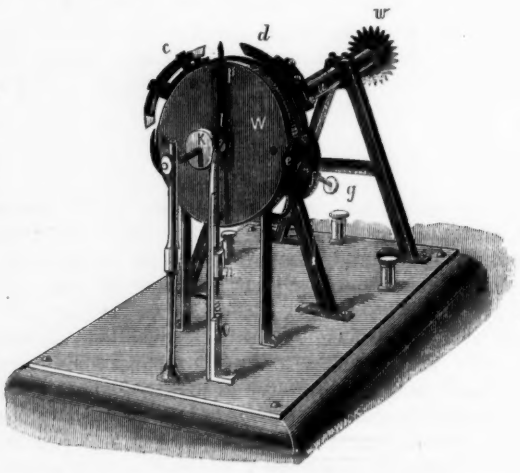
IT is somewhat curious that the "Ecclesiastical Buildings Fire" Office and other offices in which churches are insured, take no steps to ascertain whether the buildings insured by them are provided with lightning conductors or not, although we believe their policies cover damage by lightning, whether the latter causes a fire or not. In the "Articles of Enquiry" which are annually sent round by the Bishops of the Dioceses to the churchwardens of the various churches, the question is never asked—"Is the church provided with a lightning conductor?"—although this question in many cases is almost as important as the inquiry—"Is the church insured?"

MAJOR-GENERAL WEBBER, R.E., read a paper on "Lighting in Relation to Health," before the Health Congress at Hastings last week. With regard to gas, he pointed out that to counteract the possible injury to health, which no doubt was of a very insidious kind, they found certain opposing forces. Looming in the distance, but coming nearer and nearer year by year, was an important rival which science taught them must eventually supersede all other means of conveying energy, whether for lighting or for power, viz., electricity. Prof. Ayrton, in moving a vote of thanks to the reader of the paper, said that the consumption of gas was so great that gas companies' shares constituted the best investment. If gas were supplied as a cheap heating power, for which electricity was not adapted, gas companies would make still larger fortunes, and would free towns from the funereal cloud which not unfrequently lowered over them.

COX'S ELECTRICAL WATERLEVEL TRANSMITTER.

AS is well known, electrical waterlevel apparatus, *i.e.*, instruments for indicating on a dial at a distance the rise and fall of the water level in a reservoir or river, have been designed by numerous inventors. The problem to solve in such apparatus has been the transmission of currents which should be transient only, no matter how slowly the level rises or falls, so that the battery is never kept continuously at work. Mr. Cox's method of effecting the required object is very ingenious, and is deserving of notice as a clever and simple piece of mechanism.

The apparatus is shown by the figure. W is a wheel fixed to the axle, *a*, to which axle is also fixed the toothed wheel, *w*, around which the float and counterbalance chain passes. The wheel, W, has four holes near the edge of its face. *l* is a flexible hand on an insulated axle, distinct from axle *a*. This hand, which is normally kept vertical by a counterbalance weight, *n*, pushes a pin, *p*, fixed to it gently against the face of W, so that when the latter turns, this pin drops into one of the holes on the face of W when the two come opposite each other. When this takes place the hand is carried round with W, and passes *behind* one or other (according to the direction of rotation of W) of the insulated segments *c* and *d*. As the rotation is continued, say, in the direction of the hands of a watch, the hand, *l*, comes into a notch, *e*, in the small wheel, *f*.



This wheel is kept in the position shown by a counterbalance weight. The notch, *e*, in its normal position, is towards the face of W, so that when the hand, *l*, engages in it, and the rotation of W is continued, the enforced angular movement of *f* tends to force *l* outwards, and consequently to disengage its pin, *p*, from the hole into which it had dropped ; *l* being thus disengaged from W, is turned back by the action of the counterbalance weight, *n*, but as it has been bent forward it returns *in front* of the segment, *d*, and in doing so, it rubs against a platinum contact which is fixed along the front surface of *d*. The hand, *l*, after making this transient contact, returns to its normal position, and is ready for a repetition of the operation described. It is obvious that the reverse motion of W to that described causes the hand, *l*, to work over the left hand segment, *c*. The hand itself is connected through the medium of the wheel, K, and the rubbing spring, *s*, with a terminal on the base of the apparatus, whilst the contacts on the two segments are connected to two other terminals. Two circuits are formed through the centre and one or other of the two outer, terminals ; one circuit is connected with the mechanism that propels the indicator hand in one direction, and the other with the mechanism which propels it in the other direction, the battery being common to both.

ELECTRICAL TRANSMISSION OF POWER.

THE application of electricity to the transfer of motive-power to considerable distances has of late made considerable progress in Austria-Hungary. We have the pleasure of mentioning and briefly describing some such installations which are at present in the course of execution.

The Wattenser Paper Works of Mr. Kapferer is being fitted with an installation for the electric transfer of power which is to serve in the working of this manufactory.

For this purpose there is utilised a waterfall of the Wattenser Brook, in the neighbourhood of Innsbruck. By means of a turbine a force of 60 effective horse-power is obtained, which serves to drive the generating dynamo.

The current with 500 volts difference of potential given by this machine is conveyed by means of bare aerial conductors for a distance of about 1 kilometre to the works, where it actuates an electro-motor of 50 effective horse-power, which supplies the force there required.

Particular interest attaches to an installation which is now in course of construction near Wiener-Neustadt, to serve for the simultaneous production of power and light by means of alternating current transformers.

This installation serves at present for the utilisation of a water-power of 80 horse-power for the illumination of the Vienna Neustadt Brewery with about 200 glow lamps and for working the various machinery of the brewery.

At present two electro-motors of 10 horse-power and a smaller motor of 5 horse-power are being set up, so that only half the existing water-power obtainable is utilised by the combined production of light and power.

As generator, there is used an alternating current machine of the most recent construction by Ganz & Co., type A 5, yielding 25 ampères and 2,000 volts (50,000 watts), with 500 rotations per minute.

Each of the 10-horse-power motors makes 830 turns per minute, and the 5-horse-power 1,250 turns. The distance between the generating station and the point of distribution is 2,500 metres.

This installation, which was undertaken according to the advice of Herr Max von Bernd, and is being carried out under the active co-operation of this efficient electrical engineer, is the first practical application of the long-distance conductive system of Zipernowski-Deri-Blathi, with alternating current transformers, for the simultaneous distribution of electric light and motive power by means of one and the same conductive net. It cannot fail to attract the attention of electro-technical specialists.

In conclusion, we mention another interesting installation which is erected at the saw-mills of Herr Glesinger, in Ober-Turtschek, near Kremnitz, in Upper Hungary, and which is an interesting combination of electric lighting and the transfer of motive power effected by means of a continuous current.

The illumination includes about 50 glow lamps and two arc lights, arranged in the saw-mill itself and in the accessory wood yards.

A fixed electromotor of 3½ effective horse-power serves to convey the products of the mill on trucks a distance of 300 metres to the railway station, which lies at a higher level.

The trucks are drawn up by means of a rope and drum, the transfer from the motor wheel to the drum being effected by means of a spiral wheel.

All the three installations mentioned are being carried out by Ganz & Co., of Buda-Pest.

Fluted Carbons. — Mr. F. Carré, the well-known carbon pencil manufacturer, writes to *L'Electricien* protesting against the assumed paternity claimed by Sir James Douglas of the fluted carbons. Mr. Carré says that he patented this description of carbons as far back as the 19th November, 1881.

THE TRANSMISSION OF POWER BY ELECTRICITY.*

By FRANK J. SPRAGUE.

(*Concluded from page* 357.)

IN considering the transmission of power, some very curious and valuable facts may be demonstrated by a formula for determining the minimum cost of plant, where the amount of power at the generating station is practically not limited, and where there is no line loss from leakage, the line loss being measured simply by the fall in potential.

The cost of a plant of this character can be divided into five parts, that of the motors, the conductors, the line erection, the dynamos, and the power plant, whether water or steam. I will assume that the cost of the dynamos and motors is the same per horse-power or other unit, no matter what the electromotive force used. While this is not strictly true, for all practical purposes, with large units, and speaking from the commercial standpoint, it can be so assumed. This being the case, for any given power the cost of the motor is a constant, independent of the potential used. With any given motor potential, the greater the loss on the line, the less the cost of the conductors, but the greater the cost of the generators. On the other hand, the less the loss on the line, the greater its cost, but the less the cost of the generating plant. It follows, then, that the least cost to the contractor is determined when the variation in the cost of the generator is equal to that in the cost of the line, and it is to a consideration of this fact that I wish to call your attention:

We have the formula

$$C\,M = \frac{1{,}492\, n\, m\, l}{E\, v\, a}.$$

Let d equal weight of one mil-foot of copper. Then the weight per foot of the copper of our conductor would be:

$$\frac{1{,}492\, n\, m\, l\, d}{E\, v\, a}, \qquad (3)$$

and the total weight for $2\,l$ would be

$$\frac{2{,}984\, n\, m\, l^2\, d}{E\, v\, a}. \qquad (4)$$

If b is the cost in cents per pound of copper (the cost of insulation being added to cost of copper), we have for the cost of the wire in the line

$$\frac{2{,}984\, n\, m\, l^2\, d\, b}{E\, v\, a}. \qquad (5)$$

It is to be noted here that this cost, b, must be expressed so much per pound of copper. It may be that we have a line covered by an insulation of such character that for every dollar's worth of copper there may be \$3 or \$4 worth of insulation. For example, suppose that a $\frac{1}{0}$ B.W.G. wire be used, covered with an insulation that should make it cost say \$150 a thousand feet. The actual weight of copper in the line would be only 350 pounds, which at \$150 market price, would make the wire cost 43 cents per pound of copper. It is this cost, plus the cost of freight and handling, which must be used as the value of b.

Let E equal the E.M.F. at the terminals of the motor; e, the motor electromotive force; v, the fall of potential on the line; β, the commercial efficiency of the dynamo; E″, the E.M.F. of the generator, and n the number of H.P. developed by the motor. Then we have evidently

$$\frac{e}{E''}$$

as the ratio of the watt capacity of the motor and generator;

$$\frac{n}{a}$$

the H.P. of electrical energy delivered at the motor terminals;

$$\frac{E + v}{E} \times \frac{n}{a}$$

the H.P. of electrical energy delivered to the line, and

$$\frac{E + v}{E} \times \frac{n}{a} \times \frac{1}{\beta}$$

that delivered to the generator.

I think it advisable to make use of the term horse-power and commercial efficiency, for it is partly from the commercial aspect I wish to look at the problem, and it is the side which in business we must confront.

Let us further make K equal the cost in cents of the generators per horse-power required to drive them, and L the similar cost per horse-power of the steam or water plant, all of course erected in place, that is with the cost of freight, handling, insurance, and erection added to the factory or shipping cost. Then the cost per horse-power of the generating plant complete would be:

$$\frac{E + v}{E\, a\, \beta}\, n\, (K + L). \qquad (6)$$

If M is the cost of motor per horse-power developed similarly erected in place, the cost of the receiving plant would be n, M.

We now have one element which is somewhat indeterminate and is dependent chiefly upon distance and local conditions, and that is the cost of pole and line erection, and we will call this P.

Summing up our cost we have the general expressions for the cost per horse-power delivered:—

$$C = \frac{E + v}{E\, a\, \beta}\, (K + L) + \frac{2{,}984\, m\, l^2\, d\, b}{E\, v\, a} + M + \frac{P}{n} \qquad (7)$$

It is evident that this is variable, and since the costs of the motor and the line erection are arbitrary, the variation is narrowed down to the cost of the generating plant and the material in the line. It is here apparent, as already pointed out, that if we diminish the cost of the line by increasing the fall of potential, we must at the same time increase the cost of the generating plant, and on the other hand, that if the loss on the line is reduced, its cost will increase, while that of the generating plant will diminish.

Differentiating with v as the variable, we have

$$\frac{d\, c}{d\, v} = \frac{K + L}{E\, a\, \beta} - \frac{2{,}984\, m\, l^2\, d\, b}{E\, a\, v^2} \qquad (8)$$

or equating to zero

$$\frac{K + L}{\beta} = \frac{2{,}984\, m\, l^2\, d\, b}{v^2} \qquad (9)$$

which is the condition of least cost.

From (9) we have

$$v = 54{\cdot}6\, l \sqrt{\frac{m\, d\, b\, \beta}{K + L}}. \qquad (10)$$

That is, with fixed conditions of cost and efficiency of apparatus, the number of volts fall to get the minimum cost of plant is a function of the distance alone and is independent of the electromotive force used at the motor, a somewhat startling conclusion.

Substituting the equivalent value given by the equation (9) in (7) we now have for the equation of least cost,

$$C = \frac{E + v}{E\, a\, \beta}\, (K + L) + \frac{v}{E\, a\, \beta}\, (K + L) + M + \frac{P}{n}. \qquad (11)$$

The first element representing the cost of the generating plant and the second the cost of the wire per the horse-power developed by the motor. The cost of the wire is given as a ratio of the cost per horse-power of the generating plant. From this equation we have the relation:

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{v}{E + v}. \qquad (12)$$

* A Lecture delivered before the Franklin Institute, November 12th, 1888.

This is not, however, in a very useful form, and since the commercial efficiency is that with which we are concerned, we will introduce a term, designating it λ.

We have for the H.P. delivered to the generator,

$$\frac{E + v}{E\ a\ \beta}\ n$$

and n that taken out of the motor; hence we have,

$$\lambda = \frac{E\ a\ \beta}{E + v} \qquad (13)$$

or

$$v = \frac{a\ \beta - \lambda}{\lambda}\ E. \qquad (14)$$

Substituting the value of v in equation (11), we have a new form of the cost equation as follows:

$$C = \frac{K + L}{\lambda} + \frac{a\ \beta - \lambda}{a\ \beta\ \lambda}\ (K + L) + M + \frac{P}{n} \qquad (15)$$

a still simpler formula. We also have the relation,

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{a\ \beta - \lambda}{a\ \beta}. \qquad (16)$$

That is, *with any fixed couple and commercial efficiency, the cost of the wire should bear a definite and fixed ratio to the cost of the generating plant.*

But the query arises at once, is this so, no matter what the cost of the copper? And the answer is an affirmative one, and why this is so will soon be apparent.

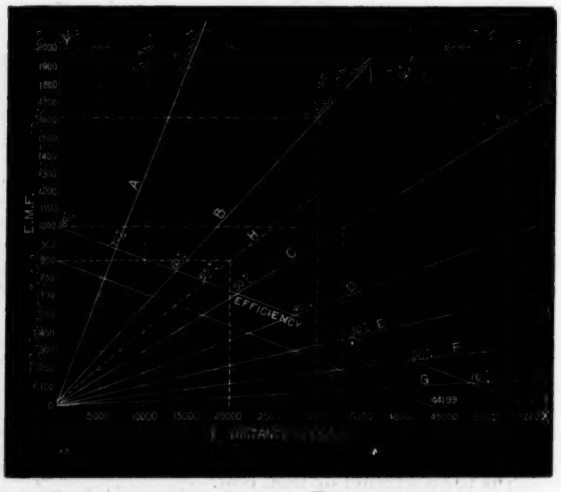


DIAGRAM 3.—LONG DISTANCE TRANSMISSION CHART.

Referring to the equation (10) and substituting for m its approximate value, 10·5, and for d its value, ·00000302705, we have:

$$v = \cdot 308\ l \sqrt{\frac{b\ \beta}{K + L}} \qquad (17)$$

Combining this with (13), we find that

$$E = \frac{\cdot 308\ l\ \lambda}{a\beta - \lambda} \sqrt{\frac{b\ \beta}{K + L}} \qquad (18)$$

We now see what influence the cost of copper has when the commercial efficiency is maintained constant, which is to vary the value of E as it increases, but only as the square root of such increase. It will be noticed also that a variation in K + L inversely affects E and v likewise as the square root.

It follows from the above that if we do not limit ourselves in the E.M.F. used, the cost per H.P. delivered exclusive of line erection, is, for least cost and for a given commercial efficiency, absolutely independent of the distance.

We are met at times with the condition that the motor potential shall not be above a given amount, and from the formula,

$$E = \frac{\cdot 308\ l\ \lambda}{a\ \beta - \lambda} \sqrt{\frac{b\ \beta}{K + L}}$$

transposed to

$$\lambda = \frac{E\ a\ \beta}{\cdot 308\ l \sqrt{\frac{b\ \beta}{K + L}} + E} \qquad (19)$$

we find at once what the efficiency of the transmission must be with a given distance, and therefore whether it is worth while to attempt the operation. On the other hand, if, for example, we make our lower limit of commercial efficiency 50 per cent., $a\ \beta = 80$ per cent., and $\beta = 90$ per cent., we have a limiting equation.

$$E = \cdot 487\ l \sqrt{\frac{b}{K + L}} \qquad (20)$$

Since the circular mils vary inversely with E v, the size, weight and cost of the wire vary directly as the cost of the generating plant, which we have already seen from another formula. To get a matter-of-fact idea of this, I will assume some values, as follows:

Let K = $45.00, L = $20.00 (say for a water-power), M = 50.00, and b = 25 cents for copper delivered on the ground.

Then we would have our formulæ for this particular case reduced to the following:

$$v = \frac{4 - 5\lambda}{5\ \lambda}\ E \qquad (21)$$

$$v = \cdot 0181\ l \qquad (22)$$

$$E = \frac{\cdot 0905\ \lambda}{4 - 5\ \lambda}\ l \qquad (23)$$

and

$$\lambda = \frac{4\ E}{5\ E + \cdot 0905\ l} \qquad (24)$$

which will give us the required elements of any single transmission under these conditions.

For example, suppose we wish to transmit 20,000 feet. The fall of potential on the line could be 362 volts, and this is independent of the commercial efficiency. If this latter is made, say 60 per cent., then E = 1,086 volts, and the potential at the terminals of the generator should be 1,448 volts. On the other hand, suppose we want to transmit a distance of 10,000 feet with a motor terminal potential of 800 volts, then λ = 65 per cent., and v = 181 volts.

We can, as I will soon show, make a graphic representation of these facts, which will save much labour and will give at a glance the various limitations.

Referring to the general equation we can make, for various efficiencies, a table as follows:

λ = 50 per cent.	$C =$	$2\ K + 2\ L + \frac{3}{4}\ (K + L) + M +$	$\frac{P}{n}$
55 „ „ „		$\frac{20}{11}\ K + \frac{20}{11}\ L + \frac{25}{44}\ (K + L) + M +$	$\frac{P}{n}$
60 „ „ „		$\frac{5}{3}\ K + \frac{5}{3}\ L + \frac{5}{12}\ (K + L) + M +$	$\frac{P}{n}$
65 „ „ „		$\frac{20}{13}\ K + \frac{20}{13}\ L + \frac{15}{52}\ (K + L) + M +$	$\frac{P}{n}$
70 „ „ „		$\frac{10}{7}\ K + \frac{10}{7}\ L + \frac{5}{28}\ (K + L) + M +$	$\frac{P}{n}$
75 „ „ „		$\frac{4}{3}\ K + \frac{4}{3}\ L + \frac{1}{12}\ (K + L) + M +$	$\frac{P}{n}$
80 „ „ „		$\frac{5}{4}\ K + \frac{5}{4}\ L +$ o $+ M +$	$\frac{P}{n}$

and substituting the assumed values K, L and M, we would have for the cost of transmission per horse-power delivered, exclusive of poles and line erection, and independently of the distance, the following table :—

Efficiency, per cent.	Water-power.	Dynamo.	Wire.	Motor.	Electrical total.	Water and electrical.
50	$40 00	$90 00	$48 75	$50 00	$188 75	$228 75
55	36 36	81 81	36 94	50 00	168 75	205 11
60	33 33	75 00	27 08	50 00	152 08	185 41
65	30 77	69 23	18 75	50 00	137 98	168 75
70	28 57	64 28	11 61	50 00	125 89	154 46
75	26 67	60 00	5 42	50 00	115 42	142 09
80	24 00	56 25	...	50 00	106 25	130 25

The graphic representation of the facts which have been set forth, and the construction of an electrical reference table, which will at once show the necessary elements, is a simple matter.

We have the equation.

$$E = \frac{\cdot 0905\ \lambda}{4 - 5\ \lambda}\ l$$

Let us lay off on the axis of x the distance in feet and on the axis of y the E.M.F. at the motor terminals.

Then for any value of λ the ratio of

$$\frac{E}{l}$$

is fixed, whatever the actual value, and we can draw the efficiency lines O A, O B, &c., for

$$\lambda = 70 \text{ per cent., } 60 \text{ per cent., \&c.,}$$

which will, with the different values of l and E, give us any required information. This, however, is not yet in a convenient and general form, and we wish to get some general intersecting efficiency line. By an inspection of the diagram we see that if a general efficiency line can be drawn, it must intersect the specific efficiency lines at such an angle that the intersected portions must be proportional to the differences of efficiencies. In other words, we must have the ratio

$$\frac{E}{\lambda}$$

for any particular value of E constant. Referring to the above equation and transposing we have,

$$\frac{E}{\lambda} = \frac{5\ E + \cdot 0905\ l}{4}. \qquad (25)$$

It is evident that if we are to get this equation to give a straight line, we must make the condition

$$\frac{E}{\lambda}$$

a constant, r. Substituting we have—

$$\frac{E}{\lambda} = r$$

and

$$r = \frac{5\ E + \cdot 0905\ l}{4}$$

which will give in a series of parallel straight lines for various values of r and E corresponding.

Let $r = 1{,}000.$

Then we have—

$$E = 1{,}000\ \lambda$$

and

$$E = \frac{4\ r - \cdot 0905\ l}{5}.$$

When

$$E \text{ and } \lambda = 0,\ 4\ r = \cdot 0905\ l$$

or

$$l = 44{,}199,$$

and when $l = 0,$

$$E = 800$$

and $\lambda = 80$ per cent.

Plotting this, we have a general efficiency line. Assuming another value for r, we get another straight line parallel to this, but one line is sufficient. It is, however, of prime importance. On it we lay off the efficiency percentages in equal increments, from 0 to 80 per cent, and the chart which needs consist only of the axes of x and y, and on which the E.M.F. and distance are laid off, and the efficiency intersecting line is ready for constant reference, and will give at a glance the graphic solution of all the ordinary elements of a transmission under the condition of least prime cost, and with the known efficiency of motors and dynamos. For example, suppose we wish to transmit a distance of 30,000 feet at a commercial efficiency of 60 per cent., what would be the required E.M.F. at the motor terminals? Drawing the efficiency line, O, B, till it meets the ordinate erected at $l = 30{,}000$, we find the E.M.F. to be 1,620 volts. On the other hand, suppose we are limited to 1,000 volts at the motor, and must have an efficiency of 50 per cent., what would be the limiting

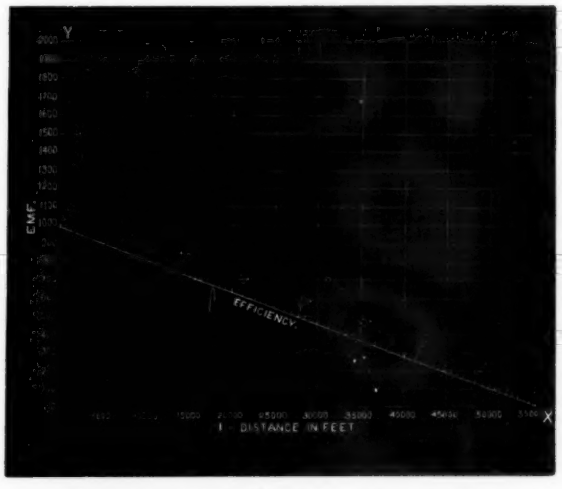


DIAGRAM 4.—LONG DISTANCE TRANSMISSION CHART.

distance? Reversing the above process, we find it to be 33,500 feet. Suppose, again, that we must operate at a distance of 20,000 feet, and are likewise limited to an E.M.F. of 800 volts at the motor, what would be the required efficiency? Through the intersection of the co-ordinates of electromotive force and distance, we draw the efficiency line, O, H, and at its intersection find the efficiency to be about 55½ per cent. Such, then, is this method of graphic determination.

Commercial practice, however, may make it inadvisable to meet every phase of a transmission just as the theory may demand, and since in manufacture it may be advisable to build motors for three standard potentials, say, for 400, 800 and 1,200 volts, allowing the dynamo to be driven at the E.M.F. demanded by theory, we may be required to make a table something like the following. It will be noted that the prices here differ somewhat from those given in the preceding examples, and are illustrative rather than perfectly accurate.

C

Distance in feet.	E.M.F. at terminals of motor.	Commercial efficiency.	PER HORSE-POWER DELIVERED BY MOTOR. Horse-power required at dynamo.	Weights in Pounds. Dynamo. Net.	Dynamo. Gross.	Motor. Net.	Motor. Gross.	Wire, uncovered.	Cost in Dollars and Cents. Water-power.	Dynamos, &c.	Uncovered wire, &c.	Motor, &c.	Total for electrical equipment.	REMARKS.
5,000	400	65	1·53	153	168	97	130	68·88	30·60	61·20	17·22	45·00	123·42	Copper, at $0.25
10,000	,,	54	1·85	185	204	,,	,,	144·32	37·00	74·00	36·08	,,	155·08	Dynamos, at $40.00
15,000	,,	47	2·13	213	234	,,	,,	210·88	42·60	85·20	52 72	,,	182·92	Motors, at $0.45
5,000	800	71	1·41	141	155	,,	,,	39·68	28·20	59·93	9·92	47·50	117·35	
10,000	,,	65	1·53	153	168	,,	,,	71·72	30·60	65·03	17·93	,,	130·46	Copper, at $0.25
15,000	,,	59	1·69	169	186	,,	,,	110·92	33·80	71·83	27·73	,,	147·06	
20,000	,,	54	1·85	185	204	,,	,,	150·32	37·00	78·63	37·58	,,	163·71	Dynamos, at $42.50
25,000	,,	50	2·00	200	220	,,	,,	187·52	40·00	85·00	46·88	,,	179·38	
30,000	,,	47	2·13	213	234	,,	,,	219·68	42·60	90·53	54·92	,,	192·95	Motors, at $47.50
35,000	,,	45	2·22	222	244	,,	,,	242·80	44·40	94·35	60·70	,,	202·55	
10,000	1,200	69	1·45	145	160	,,	,,	51·84	29·00	65·25	12·96	50·00	128·21	
15,000	,,	65	1·53	153	168	,,	,,	74·60	30·60	68·85	18·65	,,	137·50	Copper, at $0.25
20,000	,,	61	1·64	164	180	,,	,,	101·28	32·80	73 80	25·32	,,	149·12	
25,000	,,	57	1·75	175	193	,,	,,	130·80	35·00	78·75	32·70	,,	161·45	Dynamos, at $45.00
30,000	,,	54	1·85	185	204	,,	,,	156·32	37·00	83·25	39·08	,,	172·33	
35,000	,,	51	1·96	196	216	,,	,,	184·72	39·20	88·20	46·18	,,	184·32	Motors, at $50.00
40,000	,,	49	2·04	204	224	,,	,,	205·52	40·80	91·80	51·38	,,	193·18	
45,000	,,	47	2·13	213	234	,,	,,	288·44	42·60	95·85	57·11	,,	202·96	
50,000	,,	45	2·22	222	244	,,	,,	252·52	44·40	99·90	63·13	,,	213·03	

ON THE WINDING OF RESISTANCE COILS INTENDED TO BE MEASURED BY ALTERNATING CURRENTS.*

By M. G. CHAPERON.

IT has long been known that ordinary resistance coils do not lend themselves readily to measurements effected in a Wheatstone bridge by the method of alternating currents.†

When, for example, the telephone is employed as a galvanoscope, we get, with the bobbins now in use, instead of silence for the position of equilibrium, rather a bad minimum of noise as soon as the resistances of comparison exceed 2,000 ohms; with 20,000 and 50,000 we absolutely could not make exact measurements.

Having had to estimate by the alternating current method, the only one applicable in this case, certain high and polarisable resistances (apparatus for radiophony), we have been led to examine this question, and, in accordance with the advice and under the direction of M. Cornu, who had long thought that these effects were due less to self-induction than to the badly-defined phenomena that we meet with also in condensers (persistent residues, electrolysis, electrification), we endeavoured to find out whether it would be possible to suppress or diminish the defects of the resistances now in use. Kohlrausch and other physicists‡ have attributed these effects mainly to the electrostatic capacity.

This explanation is rendered very probable§ by the comparison of two windings of the same volume performed with the same wire—one simple, the other formed, like the present bobbins, of two parts, traversed in reverse directions by the current. The simple winding, associated with a rectilinear resistance on a wire bridge, gives a better minimum; but the effect of self-induction on the simple wire is much greater than on the double winding, but that of the capacity is less.

An analogous experiment shows that it is the self-induction which now predominates in the simple winding; by alternating the nature in a few layers, a considerable improvement is obtained.

These qualitative experiments suffice to indicate the line to be followed in the improvement of these apparatus, to which calculation could only be applied under very great difficulties. We must evidently conclude that we shall diminish the effects of capacity and analogous effects by diminishing, by the employment of partitions, the difference of potential in portions of the wire in contact, and the self-induction by changing as frequently as possible the direction of the winding.

It is of importance, at least for operations with alternating currents, to lessen separately the two causes of error; for the compensation which might be made between them depends on the period of variation of the current, and we could not count upon the regularity and simplicity of this latter. After numerous experiments we produced some types of coils not exceeding 25,000 ohms in one winding. They consist of a German silver wire of $\frac{4}{100}$, and all the layers of the thickness of a wire are rigorously equal, and wound in contrary rotation. The winding of these resistances is, besides, much easier than would be believed; it is performed with a machine which we have had constructed by the firm of Branville, and it is almost as rapid as that of simple bobbins.

The minimum given by these resistances on a wire bridge of ordinary sensitiveness (1) is as good as that of graphite resistances.

They have been submitted to the following verifications:—

1. Measurements of relative liquid resistances (solutions of K Cl) performed by employing comparison bobbins of 40,000 to 100,000 ohms; the hundredth has generally been obtained with a very good minimum.

2. Comparison with strong liquid resistances (tubes of sulphate of zinc), taking the measurement alternately on the same bridge with the continuous or alternating current. The identity is perfect, with the exception of now and then a little effect attributable to the polarisation of the zinc.

3. Same comparison with a graphite resistance. The difference between the measurements with the two sorts of currents is not appreciable with our instruments.

The telephone bridge which serves to make these experiments is a bridge with straight wire, somewhat similar to Kohlrausch's bridge with helical wire. It can be mounted specially so as to show the slightest traces of self-induction or capacity in a conductor. We then employ a fine wire of platinum alloy of 500 ohms, 1,000 ohms per metre and more, and as source an inductor of about equal resistance; the sensibility of the telephone for high resistances is very considerably increased by placing it in the induced circuit of a little induction coil suitably calculated. Even with this exaggerated sensibility the bobbins with alternate windings give a sufficient minimum.

* *Comptes Rendus.*

† "Bouty and Foussereau," *Journal de Physique*, Vol. IV., 1885. Kohlrausch, *Annalen*, 1885. Sheldon, *Annalen*, 1885.

‡ "Kohlrausch," *loc. cit.* Berglinski, *Annales Telegraphiques*, 1888.

§ This experiment does not, however, enable us to distinguish the capacity, properly so-called, of the electrolysis, &c.

Under the same circumstances, the best resistance boxes in use would not allow of any even approximate measurement when once the bobbins employed exceed 2,000 to 5,000 ohms.—*Comptes Rendus*, April 15th, 1889.

ELECTRICITY AND MAGNETISM AND THEIR RELATION TO VOLCANIC ACTION.

MM. FIRMIN LARROQUE and Vallapegas recently set themselves to seek out the relations between volcanic eruptions and electric or magnetic phenomena. We are indebted to *La Revue Scientifique* for the following account of the execution of the first portion of their programme :—

A. To observe conjointly : 1. Volcanic phenomena, trepidations, subterranean noises, eruptions, &c. ; to note the atmospheric circumstances which appeared to coincide with these phenomena. 2. The noises produced in the telephone, put in derivation on the earth. 3. The variations of intensity in the terrestrial magnetic field.

B. To seek if there exist any relation between the variations indicated by the instruments and the phenomena of volcanic nature.

C. In a case in which a relation should be proved, to determine whether electrical or other phenomena are the determining cause or effect of volcanic phenomena.

In order to carry out this programme, M. Vallapegas, a Portuguese geologist and an intrepid traveller, furnished with instruments and instructions from his collaborator, undertook a long journey in the volcanic regions of South America. Having been absent two years and a-half, he has already gone over a considerable extent of mountains and plains. His first station was the valley of Quito, which is encircled by two chains of volcanoes, the one eastern, the other western. Thence he descended to Chili, drawing towards the plains of Brazil and the plateaux of Bolivia and Peru. The volcanoes explored were : Puracé, Satara, Pasto, Rucu, Pinchincha, Quirotoa, Autisana, Sangay, Misti, the volcano of Atakama, Illascar, Llulaillaco, Coquimbo, Aconcagua and Tupungato.

The instruments of study were four in number and were as follows :—

1. A quadrant electrometer, derived from Thomson and Mascart electrometers, provided with a special suspension, which allowed of the quadrants and the needle being imprisoned in an hermetically closed vase, and which possesses the advantage of bearing jerking about without deterioration.

2. An electro-magnetic telephone, inserted on a line formed of an insulated copper wire with copper earth plates.

3. A Larroque geomicrophone.

4. An apparatus for measuring the magnetic field. This apparatus, which must be portable, easy to instal, and always ready to work, is composed of a strongly magnetised bar furnished in its middle with a hook which allows of its being suspended horizontally to a solid bar of Indiarubber, and bearing at each end a contact of Blake carbon, from which has been suppressed the grain of platina in order to replace it by a nickel *plaquette*. This bar being disposed parallel to the magnetised needle, there is taken for the measure of the field the variations of the attraction which one pole of the bar exercises on a soft iron armature placed in proximity.

The following are some of the results secured by M. Vallapegas by using the geomicrophone, which allows, to use his expression, "of the globe's pulse being felt." Generally speaking, volcanic actions assume a periodic character ; according to the places, the period is simple or compound, distinct or undecisive, short or prolonged. The zones of disturbance extend around the centres of subterranean action much further than has been hitherto supposed. What is known as a volcanic centre is in general a group of centres of action. For example, at Sangay, the geomicrophone revealed the existence of three active points : the most important and the only one apparent was Sangay itself, the two others being situated one to the north, the other to the west. Among the volcanoes in repose, some, which were believed absolutely calm, extinct for ever, have their depths excited by igneous matter. There are in existence in regions far removed from volcanoes, active internal fires of which the existence is far from being suspected, and with which it will be necessary one day to reckon. These results show that the geomicrophone is called upon to render great services to geologists by permitting them to follow the phases of the internal activity of the globe, of foreseeing the return of activity of volcanoes in repose, and the appearance of new volcanoes.

The electro-magnetic telephone being installed in a region removed from volcanoes, irregular noises, slightly dragging, were heard, whatever the state of the atmosphere ; these noises were probably caused by the variations of the telluric currents. If the line were installed in the latitude of a volcano in activity, independently of dragging noises, crackings were heard, simultaneously with the characteristic noises collected by the geomicrophone. At Sangay the scoria was projected every 10 or 15 minutes ; the crackings followed the same intervals, and the cracking was heard before the erruption was distinguished. These crackings remained perceptible at greater or lesser distances, failing at intervals.

The electrometer indicated an unequivocal coincidence between certain variations of the potential of the air and the volcanic phenomena. The observation was mute quite close or far away from the volcanoes ; but at a medium distance, which varied according to the locality between 8 and 20 kilometres, a movement of the needle was observed which acquired a certain amplitude, at the same time the characteristic noises of the geomicrophone and the telephone were perceived. The direction of deflection was always the same, and indicated that the air was positive.

The whole of these results prove that there exists a relation between phenomena of a volcanic nature and telluric and atmospheric electricity. The cause of the telephonic noises and the movements of the electrometer is probably unique ; it is the appearance on the terrestrial crust, in the volcanic latitudes, of negative electrical charges, determining by influence a positive electrical state of the air. If the indications of the electrometer be doubtful in the neighbourhood of a volcano, that shows that, in a certain region round the eruptive focus, the electrical state of the atmosphere is extremely troubled.

The magnetic observations do not permit of its being said whether the variations of the intensity of terrestrial magnetism have a relation to volcanic phenomena. M Vallapegas has remarked, besides, that volcanoes active or in apparent repose, in the neighbourhood of which the telephone has produced crackings, have a tendency to surround themselves with vapours, of which the density is more or less variable. The general movements of the atmosphere, tempests, and storms seem to have no influence on the internal phenomena of the globe. During an eclipse of the moon subterranean activity is notably slackened. New observations will permit of its being decided whether this slackening be due to the eclipse or not.

ELECTRIC LIGHTING IN A PIT.

A NOVELTY in the employment of electricity for lighting purposes is at present to be found at Anzin, Dèpartement du Nord, France, in the Enelos pit belonging to the Anzin Mining Company. In the beginning of 1888, owing to the passage into the Enelos pit of a large quantity of water from the Denain pits and from the Anzin torrent, it was found necessary to instal a pump underground in order to raise the water

to the surface. The amount of work to be done by the pump was such as to necessitate its being placed in a well lighted spot, both for attendance and maintenance. Naked lights were out of the question in consequence of the presence of fire-damp, and it was therefore resolved to have recourse to electricity, there being an ample supply of water-power. The water, the volume of which is estimated at 70,400 gallons every twenty-four hours, enters the pit at a depth of 340 yards and descends to the bottom—about 65 yards lower—through tubes, the delivery being almost constant. The power of this fall of water was estimated at 2 effective H.P., which could always be relied upon, and this was considered to be sufficient for driving a turbine and dynamo for 16 incandescent lamps. Accordingly the Société Gramme were instructed to lay down the plant, which consists of a No. 6 compound dynamo and turbine. The pump is fixed in a chamber quite close to the bottom of the pit, whilst the dynamo and turbine are placed about 27 yards distant from the chamber. A Deprez voltmeter has been put up in order that the attendant may at any time notice the pressure. There are twelve 16 C.P. Swan lamps. The first lights up the dynamo and turbine, the second is placed at the entrance to the chamber already mentioned, and the remainder are inside the chamber, which is consequently very brilliantly illuminated. The speed of the turbine is 1,220 revolutions per minute. The dynamo gives a current of 20 ampères at 110 volts. Since the installation was put up, last August, it has given the greatest satisfaction.

The initial cost of establishment was as follows :—

Turbine	£43	12	0
Dynamo	28	0	0
Lamps and accessories ...	6	9	6
Switchboard	8	9	0
Wiring	4	14	6
Other items	0	10	6
Total	£91	15	6

MAGNETIC PHENOMENA OF IRON-NICKEL ALLOYS.

MR. WILLIAM B. COOPER, of Philadelphia, writes as follows to the New York *Electrical Review* :—"No theory attempting to explain the phenomena of magnetism can be regarded as conclusive which fails to account for the change which magnetic metals exhibit when heated.

"It is well known that when iron is heated to a yellow red, or about 700 degrees C., it ceases to be attracted by the magnet, and careful experiments show that the range of temperature in which the greater portion of this loss occurs is about 100 degrees. Nickel has a similar critical range somewhat above the fusing point of lead, or about 350 degrees C. The critical temperatures of the magnetic oxide of iron, or loadstone, and the protosulphide, are intermediate between those of iron and nickel.

"It occurred to me that it would be interesting to examine the magnetic properties of alloys of iron and nickel, and I obtained the following interesting results :

"An alloy of three parts of iron to one part of nickel had a critical range of temperature, as nearly as I could determine by the colour, about the same as iron. When, however, the proportion of nickel in the alloy was increased to 50 per cent., the temperature at which the change occurred was a dull red heat, which is about midway between the critical ranges of the two metals.

"This impresses me as a fact of profound interest, as it might be inferred that each metal would manifest its phenomena independently of its association with the other ; yet, when the proportion of iron predominates, the nickel is subordinated to it ; when the proportions are equal, a mean is the result ; and if the nickel predominated, there is every reason to believe that it would prevail in determining the critical temperature, although I have not carried my investigations further than stated.

"I present this interesting fact relating to these important metals in the hope that it may lead to a more definite knowledge of their molecular structure, and that it may also be utilised by some able investigator to give a deeper insight into the nature of alloys and the phenomena of magnetism."

ELECTRIC LIGHT PROVISIONAL ORDERS.

BOARD OF TRADE INQUIRY.

(*Continued from page* 515.)

Upon the resumption of the inquiry before Major MARINDIN on Monday, April 29th, Mr. PEMBER, Q.C., handed in a list of shareholders of the London Electric Supply Corporation.

Mr. MOULTON, Q.C., then resumed his speech on behalf of the Chelsea Electricity Lighting Company and the Electrical Power Storage Company. The portion of the case which he considered of supreme importance for the Board of Trade to consider and decide upon was, which was the best system of supply. They were now almost at the beginning of the English public electric lighting. It should have begun some years ago, and the reason that it had not done so was not because there had been any discoveries in electricity which had seriously altered the problem, but because the legislation had stood in the way of its being carried out with any probability of commercial success until the difficulties had been removed. Otherwise the problems remained the same as in 1883, with the one exception that there had been added to the practical means of distributing electricity the transformer system, which although then proposed, was not at that time known as an important element. But it had unquestionably been prominent during the inquiry. With that single exception, the public policy had not changed in any way from what it was in '83. It was true that the new system extended the power of electric lighting, but the aims and objects which led the Board of Trade to their conclusions in '83 still remained of equal importance to what they then were. He would exemplify how the transformer system affected the previous model order and see if it justified a relaxation, or whether it did not rather increase the importance of the carefully studied obligations which were made incumbent on all the companies at that time. He submitted that so far from justifying a departure from the prudent policy of that order, its importance was only emphasised. Whilst the direct supply was almost, if not quite, beyond question the best system for the consumer, if it was to be effectively given to the public, all the obligations of the model order might be fairly insisted upon, and he thought they would be cheerfully borne by those companies who wished to do their duty to the public. But the transformer system differed from the direct supply in this : that the natural inducements to do its work thoroughly, and to make electric lighting a thing used from house-to-house, were absent ; so there was all the more reason that there should be statutory obligations to keep them up to their duty. He should exemplify that by the case of the London Electric Supply Corporation, which seemed to him a company which had seized on the one great feature of the transformer system, so that it would enable them to hold the City, and prevent any competitor coming in ; it would do that without really giving to the public electric lighting in the best way. They had seized upon it, and under the guise of "down with monopoly," he thought they were asking the Board of Trade to consent to an attempt which, if successful—and he trusted it would not be—would leave London as much at the mercy of the huge corporation as it had been at the mercy of the gas and water companies. Those were strong words, but he should support them by argument, for he believed the evidence justified them. The evidence pointed to this : that the direct supply was unquestionably the best for consumers. There was one thing at present beyond controversy. He said "at present," because he would not say what science could do in the future ; but an administrative body like the Board of Trade, which had to advise the Legislature and the local authorities, was bound to look not with credulous eyes at what was hoped for in the future. It had to take its course day-by-day by the knowledge of the day—by that which experience had shown to be certainly within the reach of practical attainment ; and it was bound to give the main, the decisive weight to that which could now be done. Although it should not set its face against the hope of future scientific advances, its action must be guided by present knowledge. It was admitted that for motive power the direct supply was the only form of supply which was useful. It was admitted in evidence that the Corporation could not supply electricity for motive power ; and it was also admitted by the Corporation witnesses that there was a demand for such a supply. The demand for gas as a source of motive power was getting more and more important. Electricity for motive power was free from the difficulties which attended gas, and it could be given in large or small quantities,

and could be used anywhere, from the parlour to the workshop, so that it had the opportunity of satisfying any desire that might exist or spring up of using motive power in domestic life, and in all the hundreds of trades affected because they were so small that they could not afford to have the ordinary source of motive power and were obliged to do things manually as they could not afford to do it mechanically. In America there had been continual working on the alternating motor, and Mr. King, who had had practical experience there, said that no motor of anything like a satisfactory kind had ever been invented, although people had been for years working at it. In choosing between the direct supply and the transformer system they would be choosing between one which was only useful for lighting and the other which was useful for every purpose for which electricity could be used. By the direct system they could use storage in several ways. Storage could be so used as to ensure the certainty of the supply, The value of that could not be too forcibly insisted upon. Perhaps the chief value of electricity was its instantaneous action. and it was absolutely free from all the troubles to which other substances were subjected. It responded at any moment to any demand upon it, and could be transferred through the ordinary means of carriage. But the danger to be feared was that a breakdown in a system might lead to immediate extinction. They had heard a great deal about the security against that—that they would switch on to another stream, or obtain another supply. They might be able to do that very often, but it could not be invariably relied upon. A main, or several mains, might break down, and as that could not be foreseen it could not be provided against. And they had heard from the evidence of what accidents did happen from the transformer system which supplied from moment to moment, and which leave the consumers in darkness. But the direct supply with the use of storage would prevent the possibility of immediate extinction. In many of the districts for which the orders were sought to be applied there were a number of theatres and large assembly rooms, and in which were gathered great numbers of persons, so that an extinction would be of the utmost inconvenience and possible danger. There was thus an almost necessary demand for storage which could be used for the theatres. If the supply were such that the individual could use storage, then it might fairly be said that in places like theatres where immediate extinction would be dangerous the direct supply with storage would especially meet the requirements and be a great advantage. The transformer system was just as useless for that as for public storage. It was impossible to use the transformer system for the purpose of storage batteries. In America, where there were 120 installations, and where alone the transformer system had been carried out on a large scale, they found that they had never yet been successful with the high tensions. He appealed to the London Electric Supply Corporation, as to what they intended to do. Did they intend to work their alternating dynamos on the same circuit? No; it would be an enormous advantage if they could do so, but they were not audacious enough to say that even this most elaborate electrical machinery was of practical use in working into a network. The fact that that company did not attempt to do it was sufficient to support him in what he said, that they could not rely on being able to work transformers into different parts of the same network, but with the direct supply it did not matter how large their network was, whether they were working from storage or not, or where their generating stations were, they could fit into this network by the direct supply at as many points as they liked, and keep the pressure at what it ought to be; and they could ensure having a network depending upon a vast number of generating units almost independent of the failure of each other, diminish the danger of a large portion of London being put in sudden darkness, and thus give the public greater confidence in electric light. Now, let them look at the alternative on the other side. They must have small networks and many of them with all the complications that consequently arise, each one depending upon a separate unit, or they must have large networks depending on gigantic machines with all their disadvantages and exposed to the danger of being thrown into darkness as these gigantic machines generally fall out of gear. As to the question of public danger, this transformer system was a system which proposed to bring into every house electricity under circumstances dangerous to life and property. He quite admitted the value of the safeguards against that danger, and that they diminished it enormously, but still it remained true that they brought into houses electricity under dangerous circumstances, and in a way in which he could not see how they could prevent imprudence or carelessness from making that danger a very, very probable one. In the direct system, however, no electricity was brought into the house except under perfectly safe circumstances. Another point in his favour which was even more important was that they did not use their high tension electricity at the time that they were using the low tension electricity at all—in other words, at the time that they were using their low tension electricity, so far as anything that had to do with the source of their low tension electricity, there might just as well be no high tension electricity at all. No battery could be on the charging circuit and on the discharging circuit at the same time; and the danger of the use of the high tension current, apart from the question of the continuous current, was a danger not to be put in any way on the same level as the danger of the transformer system. Further than that, was there anything to show that the supply by the direct system was inferior? Had there been a single suggestion that the supply in the alternating transformer system was a better supply to the customer than that of the direct system? He had not heard a single suggestion that the direct supply was inferior to the transformer supply in any one point, and the evidence of those of actual experience clearly pointed to an enormous advantage in superiority in the direct supply. Well, if the customer was better off with the direct supply than the alternating supply, why should not he get it? If the latter were not really cheaper, he did not see what there was to recommend it. If they contented themselves with moderate areas, the direct supply was cheaper; there was no controversy about that. They had no figures to show what the transformer system actually and really cost; but nobody contended that for moderate areas that it was really cheaper. Let them take the evidence of Mr. Siemens, who was called on behalf of the transformer system. His firm had installations at St. Petersburg, Moscow, Munich, Darmstadt, Berlin, and other places, and in not one of these had they adopted the transformer system; and he said that provided the stations were not too large, and they could get a suitable site, he would prefer for London such a system as that used at Darmstadt. Mr. Siemens thought the Darmstadt system the best. Then Sir Wm. Thomson, who was equally frank, said he preferred the direct supply and the storage batteries, but only, he said, for small areas; and who was called who said the transformer was better for moderate-sized districts? He could find nobody; and nobody said that the direct supply was more expensive if the areas were moderate in size, but on the contrary Mr. Crompton most emphatically said it was cheaper. Mr. Knight said that when they had got straggling areas the transformer system was the best; but there was nothing which had yet been found in the use of the transformer system which contradicted the opinion that the direct supply was cheaper where they did not have straggling districts. The question really was, were they going to make the companies keep to certain areas, or were they going to give them huge areas and let them pick out what parts they liked? As to the Metropolitan Company, if they compared its capital with the area it was applying for, it was the most miserably poor company that had come before them. Even the London asked, he thought, for only something like two-thirds of what the Metropolitan Company asked for, and it had got a capital of about two-and-a-half times as much. There was nothing to recommend the Metropolitan principle except the principle of the company, "Ask, and ye shall have." (Laughter.) And the London company came before them and said: "We are a transformer company. We intend to carry out the idea of transformation in its most advanced form. We intend to have our centre of generation miles out of London. We intend to have mains at enormous pressure," and so on; and consequently they wanted an enormous piece of London given them. Just let them consider what that meant. They had taken, he quite admitted, the transformer system and pushed it to its legitimate ends, and in that way they made it possible for them to pitch on any part of their enormous area and light it, and they could do it. The whole of their arrangements were made so that they could pick out points which to other electrical systems would be very distant. Supposing they got the area, they would be able to do the best piece of the City, the best piece of Chelsea, the best piece of the Strand, Marylebone, and all the other places for which they were applying. It was not pretended by them, however, that there was any necessity or any real inducement for them to light the whole of a district in which their mains lay if they could get a very large supply round their distributing stations. So, in other words, they had adopted that very system which enabled them to take the plums, and they asked for a large enough slice of London to give them sufficient plums. Now what did the Board of Trade do in 1883? The object of its legislation then was not to allow a company to take a district and have powers over that district, unless there was a reasonable certainty that they would put the electric light within the reach of the whole people of that district. In those days the Board of Trade knew perfectly well that the companies to which they were giving these powers were companies who had only one hope, and that was to develop electric lighting in that area close to where their works were. The companies then had no opportunity of picking out the plums. They were local companies. The Board of Trade provided for compulsory mains and made the companies allocate to the district over which they had powers a sufficient amount of capital to do it thoroughly. Then they stipulated if they took another district that they should allocate sufficient capital to do that district, and if they applied for a piece which did not fairly represent the remainder of the area, the Board of Trade could refuse to allow them to have it unless they added such portions to it as made it fairly represent the area. And above all, there was a very clear understanding that these were statutory monopolies, and if the companies did not do their work thoroughly other companies would be allowed to go in. Now the London Corporation was asking for this large area; and what did it undertake to do in the way of work? Not a single yard of mains when it lodged its order. Now, however, they undertook to do in Chelsea the same compulsory mains as the Chelsea Company undertook, in 1886, to lay in order to get their order. And now to get the power to do that little area the Corporation at last undertook to put down those compulsory mains. That out of the 16 square miles of London for which they sought power was the only obligation they took on their shoulders, for they only took that on their shoulders because they thought they had no chance of getting to Chelsea otherwise. Yet they asked for about 30 times as much as his (Mr. Moulton's) clients did. If the obligation was put upon the London Corporation, where would their capital be? The enormous amount of plant they spoke of

they admitted would be just enough for a quarter of a million of people, and they never thought what the capital would be that would be necessary to light the area they had taken; in fact, if it came to the whole duty the London Corporation would have to abandon half or three-quarters of its area before it could show it had money to do the rest. Another point was the capital allocated to do these areas. There, again, what had the London Corporation done? They had left that out entirely. They did not allocate a single sixpence to any portion of the district. What was the reason? The reason was obvious—they did not mean to do London. They only meant to do such bits as would prevent any other company doing their leavings or competing with them in the bits they did. It would have been the easiest plan by far to have stuck to the model order of 1883, but the London company had purposely omitted the several clauses which gave them the greatest difficulty; they omitted them because they were actually fatal to the scheme they had got. They intended to have roving powers over that area, but did not intend to confine themselves to any portion of it. Thus they found that the corporation came with a capital wholly inadequate to do the duties it took on its shoulders; and if the Board of Trade gave it anything like the area it asked for they would give it the opportunity of getting a large supply without it being a general supply throughout the whole of its own district. The consequence would be that by them all the good places would be occupied, and the leavings would be for other companies. But if that were permitted, where would other companies get capital to do the rest? What this would lead to would be that London electric lighting would be in the hands of a company that might do it or not do it, as it liked, but would have a power absolutely irresistible of preventing it being done thoroughly by any other company. He (Mr. Moulton) who appeared for companies who were asking for small areas which they were certainly capable of supplying, asked the Board of Trade, through Major Marindin, to report that the evidence before them established that the best and the most efficient supply to the consumer was that of the direct system; that it was more useful, that it was safer, that if they kept companies to comparatively small districts they could get that supply as cheaply as they could get it by the transformer system, and that it was only through certain companies spreading their mains over a large area, which they were not going to do thoroughly, that the cheapness of the transformer system—if there were any real cheapness—could come in; in other words, if they were going to do the district thoroughly, the direct supply was cheaper; but if they were only to do bits, then the advantages of the transformer system came out. Turning to the question of competition, was there anything, he asked, that had been brought forward at that enquiry which would justify the Board of Trade in coming to a different conclusion from that which it came to in 1883, viz., that potential competition and judicious districting were better for the public than competition in the same area? He ventured to think there was nothing whatever. What the Board of Trade relied on so much was the competition of gas; and was there any reason to think that gas was now less efficient? Why, if they could compare what gas could do in 1882 and what it could do now, they would find that the competition in gas now was immensely more dangerous and a more potent rival to electric lighting than it was 1882. Mineral oil was also a more formidable rival than in 1882. Better forms of lamps had been invented which made it a more serious competitor, and altogether the rivalry which the electric light had now to overcome partly by cheapness, partly by efficiency, and partly by its own inherent disadvantages, were more than ever they were in 1882; and it appeared to him that the whole tendency of the evidence was in favour, not of solid competition, but of potential competition—that was competition by other companies who could come in and occupy the ground of those who were not doing their work well. It was only by keeping companies to moderate areas and making them do those thoroughly that they could secure a good supply, and make this competition an effective influence in keeping the companies up to their work. The London Corporation did not show any willingness to do the work for anything less than the others offered to do it for. This question of the minimum price was an important one, because it showed that the eightpenny Board of Trade limit was nearly what they meant to charge.

Mr. PEMBER, Q.C.: Would you tell us what your Chelsea Company propose to charge?

Mr. MOULTON, Q.C., said that under the Act of 1882 it was 10d., but that which they now asked for was 8d. Now, there was not the slightest evidence that the Corporation meant to charge less, and nobody could charge more; so that there they had that company applying for those special privileges, and not suggesting in any way that it could afford to do the work for less; in fact, that showed that they were afraid to undertake to do it for less than their competitors. It was admitted (Mr. Moulton continued) that it was best to have a small generating unit, and that that was the most economical form in which they could get their power; but instead of adhering to this principle the London took a unit of a gigantic size, and why? He really could not tell unless they expected to be able to deal with the electric lighting in distinct batches and did not expect to have the ordinary task put upon their shoulders. Why they should come before the inspector and put before him, as candidates for these large powers, a system which was experimental from one end to the other, if there were not some reason of that kind, he could not understand. It began with a generating unit of 10,000 horse-power, which was enough to do 10,000 lamps. Then the company admits that the dynamo would be twenty times larger than any dynamo ever before used, and that the voltage would be ten times more than that used in America, and four times more than that used in England. And this scheme, which, if it broke down, would discredit electric lighting, this huge scheme was admitted to be experimental from beginning to end, and it was admitted that the experiment would be tried on a scale which would endanger human life and property if the safeguards which were relied upon should turn out defective. Altogether, they were asking for privileges without undertaking to do the thing more cheaply, and with the admission, practically, that they would do it more inefficiently, and that the public would be at their mercy. The system that he (Mr. Moulton) supported was a system that had been well tried, and tried with success, and had given a good supply at a reasonable price. As to the particular localities to which his orders referred, let him take the Chelsea order. His company stood in this position: It obtained an order under the 1882 Act in 1886. For the first two years it did nothing. As soon as the 1888 Act passed it at once got its capital. It got an order which obliged it to do certain portions of Chelsea, putting down mains throughout, and as soon as it got its capital it set to work, and everyone of the mains had been laid down; the supply was sufficient for all who wished to be supplied, and it had a generating station much larger than was necessary. It had shown that it was not only able to do the work it undertook to do, but it had also shown that it was willing and able to extend its area and take in new parts. Under those circumstances what happened? The Grosvenor Gallery Company, and not under a Provisional Order, came in, and was admitted to remain in; and this he thought was an instance of the shortsighted greediness that distinguished some of their local authorities. (Laughter.) Why should a company under those circumstances—doing a remunerative work, and putting down the necessary mains—be subject to competition of that kind at the request of the local authority? The Chelsea Company, as he had said, not only did what they undertook to do, but more, and even under these circumstances the London Company now took up the obligations of the Grosvenor Gallery Company, and applied for permission and undertook to put down mains in the same streets in which the Chelsea Company had put theirs down. Could they have anything more to show the wastefulness of competition, and the greediness of certain companies? If they were trying to do the best for their district, they would try and extend their electric lighting; but they must go and put down, side by side with every main of the Chelsea Company, another main, although he did not suppose there were 50, certainly not 100, houses in that district ready to take electric lighting. If such were the spirit that animated local authorities, the public would soon find that, instead of their being benefitted, they would be very much injured. Anyone who thought otherwise could be only one step removed from an imbecile in the matter. (Laughter.) The Board of Trade, he held, should refuse to allow the London Company to come into this area until they had some evidence that the Chelsea Company was not doing its work. The Chelsea Company also asked for a piece of Kensington and a piece of Belgravia. With regard to Kensington, the vestry had given his company a very small portion of the district, and a portion they could work with the greatest ease from their generating station.

Major MARINDIN: Do you accept the vestry's decision?

Mr. MOULTON replied that the vestry had not given them all they asked for, but they were quite satisfied to take exactly what the vestry gave them. There were several alterations suggested by the vestry, but he thought they were fully considered in 1883, and he doubted very much if it would be considered necessary to alter the terms of the provisional order. Coming to Belgravia, they applied for a district there which was very well situated with regard to their generating station and works. They proposed to put mains through the whole of that area. They had got the necessary capital to do the work, and they had a district which, from the locality, would be naturally supplied from the generating station there. The district could not be better off in that respect. The parish, however, objected because they said the company did not undertake to do the whole of the parish; but the parish boundaries, he contended, were not what they ought to go by in that district, the districts being quite distinct; and he could not think that the Board of Trade would be justified in saying that there was any sufficient reason why the company should be refused. They now came to the Electrical Power Storage Company. The parts they applied for were Paddington and St. Martin's-in-the-Fields in the Strand. As to Paddington, he believed that the opposition of the vestry, who, considering that they themselves should undertake to light Paddington, would not long be continued, and that the company would soon get the assent of the vestry to their proposal. The company undertook to put down £30,000, which would thoroughly do the work they had undertaken, and they were willing to extend their works to other parts of the district. He therefore thought the Board of Trade ought to report this as a good scheme. With regard to St. Martin's-in-the-Field, all he could say was that he believed they were the only one of all the competing companies that were willing to undertake the obligation of compulsory works, and this, he submitted, gave them the preference; and he submitted that this order should be given to his clients. To the St. Martin's-in-the-Fields in the Strand they had the hot opposition of the local authority there. The Strand district was thickly studded with theatres and assembly rooms, and the Board of Trade, in his opinion, could not say that the general supply of an alternating character was suitable for the public wants in a district of that kind. The supply ought to be one that could be relied upon. The importance of the electric light in theatres was admitted, because not only was it advantageous to the people who

frequented the theatre but it lessened the danger of fire. For the Strand, he thought, the only application that should receive the sanction of the Board of Trade was that of the Electrical Power Storage Company, which gave a direct supply. In conclusion, Mr. Moulton said, that the more he looked at the position and system of the London Electric Supply Corporation, the more he thought it was an attempt to hold London without lighting it. The difference between the two types of electric lighting was like the difference between a set of colonists and an army of occupation. What was sought by the London Corporation was to occupy London with a system only half thought out and experimental. It showed to him that they appreciated being first in the field. The inspector could not look into the details of the case without feeling that it was done in such haste that in addition to its being experimental, they had not even considered what they should do. With regard to connecting their mains to earth that was an important point, for the insurance companies in America refused to put transformers into the house. They had been referred to the rules of the Phœnix Fire Office, but one of those rules was to the effect that all the secondary circuits should be insulated. But Sir William Thomson said that if they were insulated the people who used them might be subjected to a shock of 2,500 volts, the magnitude of which shock was sufficient to cause death. That showed that the advocates of the corporation had not thought out their system. They did not say whether they could connect to earth or not. They did not say what they were going to do. Not only was the system experimental, but even the methods of doing it had not been thought out. The only meaning of that was that they wanted to be able to make a huge corporation to hold London for electric light, and their cry of "No monopoly" was simply to cover an attempt to win a monopoly in the only way monopolies were won in England, viz., by getting legislative privileges embodied in and exercised by the powers of a huge corporation which by command of the field and of capital would be able to deter or terrify anybody else from entering into serious competition with them. If those privileges were granted and London surrendered to the corporation upon their terms, what he felt was that electric lighting in London would be at the suffrage not of the legislature, but of the London Corporation.

Mr. C. A. CRIPPS, replying for the Metropolitan Electric Supply Company, first dealt with Mr. Moulton's arguments as to districting as against competition, and said that those arguments were based upon two contentions. It was suggested first that the matter of districting against competition was settled once for all by the Board of Trade in 1883. Not only had that which passed in 1883 been greatly exaggerated, but the subsequent history of the question showed that there had been no final settlement of the matter in that year. It was suggested that in the Metropolitan Order the plums had been picked out, but that was not so. On the other hand, the Chelsea company, which made the suggestion, was the very company which, under its compulsory area system, had picked out the plums which they said the Metropolitan would do if they had the opportunity. But the Metropolitan could be compelled to supply any part of the district under a form of requisition, and they really desired to place the whole of the district on the same footing. The question of districting as against competing occurred in nearly every area. The attitude taken up in 1883 was shown from the following clause which was approved by the Board of Trade:—"It must be remembered that whilst, on the one hand, it is important to prevent the public from suffering the evils which they suffered from the perpetual monopolies granted to gas and water companies, it is, on the other hand, no less important to offer such inducements to solvent and prudent investors as may induce them to invest capital in this novel undertaking." The only class of investors which the inspector had before him were the shareholders who had invested in the Metropolitan or the London company. There had been a great advance in the science of electricity since 1883, in which year the Board of Trade gave a limited monopoly, on the ground that the science at that time was in an experimental condition, and that it was necessary to give special terms on that very basis; but now the period of experiment had passed away, and the period of certainty in electricity as a science had taken its place. Of course, there were minor difficulties, but they were certain to be overcome, and no one could have attended the enquiry without having come to the conclusion that a vast progress had been made in the state of the science since 1883. The question of districting was not settled in one way or the other in that year, as was shown by the letter which had been written by the Board of Trade to Lord Rosebery, in reference to this very question. It was, in fact, one of the crucial points which had to be decided. That letter contained the following:—"In dealing with these applications the Board of Trade are at once confronted with two important questions of principle: (1) What should be the extent and nature of the area to be granted; (2) should or should not concurrent powers be granted to two or more companies within the same area." Those two points were the very ones upon which Mr. Moulton had laid so much stress, as if they had been finally settled. Then the letter also stated:—"As regards the former many considerations must be taken into account, *e.g.*, what is the financial position of the undertakers applying for statutory powers in any given area; how far any one company would be in a position satisfactorily to supply such an area; and in connection with this much would depend on what distance electrical energy for electric lighting purposes can be safely and conveniently furnished from a central station." The company which he represented had a total population in their area of 900,000 persons, and they had already made provision for £350,000, which would go a very long way to supplying the whole demand they expected. There was no doubt whatever that financially their company was sound and fully able to carry out all the obligations of their area under the order. They had made arrangements by their generating station for any immediate supply that might be expected, and there would be no difficulty whatever in increasing the number of operating stations so soon and so far as a further supply was needed. Their system could be relied upon both for the supply and in the matter of safety. As to whether concurrent powers should be granted to two or more companies, he did not think it necessary for the Board to lay down one overbearing principle which would apply in every district, whether the local authorities desired it or not. They should, however, look to the views of the local authority in each given locality. Where they asked for competition, and the companies were willing to give it, it should be allowed. The Metropolitan Company were willing to go anywhere as a competing company because they believed their finances were absolutely sound and that their position was the best; but they did not desire to override the wishes of the local authorities. A great deal had been said about the appropriation of capital to a given area, but he did not think that any such appropriation should be insisted upon in their case, because they were giving the strongest possible appropriation in the guarantee of the erection of sites in the various districts. The capital of the company was actually subscribed for at the present time, whereas the Chelsea Company, as to capital, was in by no means a good position. As to the Electrical Power Storage Company, he desired to point out that they were not the real promoters of the order for which they were asking the sanction of the Board of Trade. Being a manufacturing company they had no intention of carrying out the order, and they said themselves that if it were granted they were prepared to deal with it either with or without consideration. But it was contrary to precedent to grant any powers to a company in such a position as that. Immediately they became a statutory company under a confirmatory order they were debarred from transferring their rights without a further Act of Parliament. The real promoter for this inquiry should be a genuine one in the interests of the metropolis, and that could not be said of the Electrical Power Storage Company. The Strand District Board would not have anything to with them as they did not look upon them as a *bona fide* company for lighting the district, but simply as a manufacturing company desiring to benefit itself by means of another company. By section 1 of the Act of 1888, the wishes of the local authority must be considered, and the Metropolitan Company had special reasons to pay attention to that section, because when last year they were seeking Provisional Orders from the Board of Trade they were not allowed to proceed unless they had the consent of the local authority. So far as Paddington was concerned they were a dissentient authority, and the Metropolitan Company must bear the burden of that section of the Act. Still, if the inspector thought there was no reason why they should not have powers against the consent of the local authority they would not press the order; but he (Mr. Cripps) would leave it to the Board of Trade to say what the real nature of that dissent of the local authority was.

Major MARINDIN said that they had passed a decided resolution to oppose all Provisional Orders and licenses.

Mr. CRIPPS then alluded to the case of Marylebone, for which he said they had an order arranged with the consent of the local authority, and their only competitors were the London Company who were applying for only the southern or better portion of the district. As to the question of price he first thought there was no difference in that which had been arranged in the orders, and that which the company were prepared to give to the Marylebone district; but he found that in one case the minimum was 15 units, and in the other two units, whereas in one case the small consumer could not get the benefit of the lighting, in the other he could. Dealing next with the South London order of the company, Mr. Cripps said there was no opposition, and Lambeth preferred the Metropolitan to the London Company, because the Metropolitan applied for the whole district, whereas the London only picked out a quarter, and that the best portion. But there were certain conditions—and if insisted upon he thought they could not be agreed to—which the Lambeth Vestry wished to insert in the order. One was with reference to the obligation to light certain main streets, and practically the whole length was about 34 miles, and he did not think the company would get a penny out of that. They also wanted a strong clause inserted as to overhead wires.

The inquiry then adjourned till Tuesday.

The 17th day's proceedings of the inquiry commenced with the continuation by Mr. CRIPPS of his reply for the Metropolitan Company. He said that the company he represented were prepared as far as possible to meet the objections of the City authorities by having a station in the City. The Commissioners of Sewers asked for districting and not competition, and there, again, the Metropolitan Company were ready to meet them. They were confident in their system and were willing to compete everywhere, but at the same time they wished to obtain the consent of the local authority wherever they could. The objections taken by Mr. Preece were chiefly applicable to the London Electric Supply Corporation and not to the Metropolitan Company's system. Judging from the evidence of Mr. Preece, the Commissioners of Sewers and the

Metropolitan Company were on somewhat the same footing, for he advised a system of electricity by means of alternating current and the transformer system, which was the Metropolitan system. And he pointed out that it would not be wise to concentrate all their eggs in one basket. Mr. Preece objected to the connection of Deptford and London by means of their mains, and said he regarded the proposals of the London Electric Supply Corporation as to their mains, as very objectionable. He also said their form of mains was not at all in consonance with the rest of their scheme, and that it would require most mature consideration before being adopted. That general statement of Mr. Preece was quite sufficient for his (Mr. Cripps's) purpose, as Mr. Preece favoured a method of alternating current and the transformer system, there could not be any consistent objection by the City authorities to the Metropolitan Company's system. But as to the London Corporation, there was no doubt that it was a gigantic experiment. Mr. Preece had pointed to the probable telegraphic and telephonic disturbance which was likely to result therefrom unless the main could be laid in an absolutely straight line. But the important question was, whether it could be laid in an absolutely straight line. The Metropolitan Electric Lighting Company had actually entered into negotiations for carrying out their system and had spent money for the purpose of stations. Mr. Cripps, alluding to the agreement which the company had entered into with the Strand District Board of Works, said that in negotiating it, the Metropolitan Company had been perfectly straightforward throughout. The District Board had written identical letters to both the London Corporation and the Metropolitan Company and negotiations with both were entered into, but in the former case they had resulted in nothing. Complaint was made by the London Electric Lighting Corporation that they were not made acquainted with the terms of the agreement; but although there was no obligation to disclose the terms to the London Corporation, as a matter of fact, their advisers were conversant with the terms of the agreement, and the evidence was conclusive on that point. His company had never sought for an exclusive agreement; and when negotiating with the Strand District Board they were advocating competition. The Strand agreement had been attacked by two different bodies for very inconsistent reasons. Mr. Pember, as representing the London Corporation, had stated that the agreement was an improper one, and was contrary to the policy of Parliament, and should not be sanctioned by the Board of Trade; while Mr. Jones, for the St. Giles's District Board of Works, said if these terms were given to the Strand, they should be given to his own and other local bodies. There were a large number of questions yet to be worked out, both as regarded system and cost. As to the question of principle adopted in matters of this kind of Parliament, from the company's point of view the agreement was a concession enormously in favour of the local authority and the consumer, and therefore it ought to be gratefully accepted. Supposing two railway companies were coming into a district and one was *bona fide* offering better terms than the other, why should not the district have the company which offered the better terms? On the subject of price, Mr. Cripps felt he was on a firm basis. What was objected to more than the actual price was its periodical revision. But that was a principle which was admitted by Parliament in regard to the gas companies. No doubt, the Metropolitan Company would rather have their order without revision of price, but where they had a customer taking a commodity for a period of 42 years, it was not very unreasonable with such a subject matter as electricity that they should have a revision of prices from time to time. This argument was specially appliable to the question of electric lighting, because although electric lighting was no longer in quite the same experimental condition as it was in 1883, yet there were a very large number of questions still to be worked out by them as regarded system and cost. Why should not a district have the company which offered the better terms in this matter of revision of prices? What was there inconsistent in this question of revision of price, except that the corporation might perhaps fear and dread it? What had been the suggestion here from his friend. He appeared to exclaim: "Oh, electric lighting is an experimental matter; we fear we shall not get any profits until after 42 years." He (Mr. Cripps) had no such fear as that; he did not fear anything in the shape of revision of prices. Neither did he apprehend that the arbitrator would act unfairly as between the company and the consumers. On the contrary, he had every confidence that the company would be fairly protected, and, on the other hand, that the consumers would have fair consideration. He did not know what his friend meant, when he said that the legitimate profits of the company might be taken away under this system of revision. That was not his (Mr. Cripps's) experience of arbitrators, for from his experience they acted fairly between the parties which came before them; and if the prices should be reduced at the end of seven years it would be fairly done. This company did not want to make what might be called distorted profits, they only wanted to make fair profits as fair commercial dealers, and were quite content to believe that the arbitrators would guarantee them in that position. As this had been dealt with as a question of principle, he should like to call attention to one or two similar cases where the actual point of revision of prices had been considered. In the early gas acts there was revision of prices, but the sliding scale had somewhat superseded that. Still, that was on the principle of a revision of price, so that when an electric lighting company offered terms they deemed beneficial to the company and the customers, were those terms to be rejected on the suggestion of a competing company? He certainly thought not. The gas companies had been guaranteed a 10 per cent. dividend, but the Metropolitan Company went for a revision of price without even that guarantee. Mr. Cripps then proceeded to compare the merits of the respective companies, and said that as to economy of installation, including distributing mains, much criticism had been directed against his company by the advocates of the direct system, but there had been nothing proved against the alternating system to show that it was dearer either in installation or distributing mains than what was proposed by the direct system. It was a question of the difference and extra cost of accumulators on the one side, and the extra cost of generating plant on the other. He considered that the accumulator was more expensive than the extra generating plant. It was admitted that the distributing main of the direct was more expensive than that of the alternating system. As to working apart from installation, they had to compare the waste of the accumulator with the waste in loss of working the engines, and they had to bear in mind also the question of efficiency as to product, and the evidence was all in favour of the alternating system showing a much larger efficiency of product than from the direct system. The loss of power from the accumulators under the direct system would be 30 per cent. less under the transformer system. Sir William Thomson was asked the plain question, "What is in your opinion the best form of reserve power?" and he replied, "Reserve engines for large works at central stations; but for small electric lighting and isolated stations storage batteries were very valuable, but for large works reserve engine power is the best." Then as to the wearing of the accumulators he said: "A positive plate wears out in about two years." By their system Mr. Cripps believed that they could run in parallel, but even if they could not they could start a new engine and get it to run in about half a minute's time. The question as to whether they could work in parallel was the only experimental point about their system. By the evidence it was clear that before there was an absolute failure of the machine there was some warning, and he had asked the question of one of the witnesses, "Would that warning be sufficient to enable you to switch over the circuit?" to which the answer was, "I should think so, certainly." He would take his stand upon that. The general blow-ups which had been alluded to did not occur so rapidly but that they could thus be provided against, as there would be sufficient warning to get a new engine to work. Another criticism raised on the alternating system was as regarded variation of pressure, but not a word had been heard about it since the evidence of Dr. Hopkinson had been considered. He was asked: "As regarded variation of pressure under the system proposed by the Metropolitan Company, would the percentage in variation be slight?" His answer was, "Yes; it could be reduced almost as low as you pleased." Again, asked, "What in your opinion can the variation be reduced to in the main?" he said, "It can be reduced to nil."

The INSPECTOR pointed out that in another part of his evidence Dr. Hopkinson had put the variation at 1·40.

Mr. CRIPPS admitted that was so. Then, referring to the safety of the voltage, he said that a gentleman from America had mentioned the unfortunate fact of a friend of his having been seriously injured by a shock of 1,000 volts. But that was not a consumer—it was an engineer. (Laughter.) He (Mr. Cripps) did not consider it a laughing matter, but meant that engineers dealing with systems of electricity were subject to risks which did not affect the consumers at all. He did not intend anything derogatory to the engineer, and was sorry that he was paralysed; but he was in altogether a different position to the general consumers. Subject to that one unfortunate accident in America no consumer had received any injury under the pressure of 1,000 volts. There was a consensus of opinion that the Metropolitan system was as safe as the direct, so far certainly as the consumer was concerned.

(To be continued.)

THE NEW TELEPHONE COMPANY'S COLLAPSE.

WE read that the Town Clerk of Stockport has reported to the Watch Committee that Mr. George Durham, the contractor for the supply and erection of the lines and apparatus for fire alarm telephones, had called upon him with a circular letter which he had received from the New Telephone Company, Limited, who supplied him with the telephones, wherein it was stated that an injunction had been obtained against them by the United Telephone Company, Limited, restraining the user of such telephones except by the licensees of the United Telephone Company, Limited, and that in consequence the telephones sold to him would have to be given up within a month from the 13th April, all royalties to be paid to the United Telephone Company, Limited, for user thereof.

Other well-known firms in town and country are in a similar predicament, and much discontent is generally shown with the New Company's directors, for we understand that traders were clearly given to under-

stand that a large fighting fund was available, and that no such course as that which has just transpired could possibly happen. Several important firms are now seriously considering the advisability of bringing a law suit against the company, and its directors individually, with respect to their liability on the question of guarantees, and we think that such a combined effort on the part of those who have been so severely hit might result in securing compensation to themselves and satisfaction to their customers.

At all events, considering the specious promises which the New Telephone Company made to its *clientèle*, we certainly think this is a case in which some effort should be made to secure just rights, for although it is rather late in the day to fight with the United, whose patents will soon fall through, the company should have been prepared to protect its customers on all points. Perhaps, some electrical traders may consider it worth while to prepare a plan of campaign.

What say Messrs. Tasker, of Sheffield, or Laurence, Paris & Scott, of Norwich ?

NOTES.

The Electric Light and Power at Bellegarde.—The central station at Bellegarde, Ain, was one of the first in France, having been established in 1884, since which time it has been steadily extending its operations. After having supplied current for lighting the streets, for public buildings, and for private houses, the company has now gone in for distributing power to a distance of three miles from the works. The price per annum is at the rate of 200 francs (£8) per H.P., or 150 francs (£6) when over 50 H.P. is taken. The current is distributed at 100 volts when the power taken is under 40 H.P., and at ·6 mile distance, and at 300 volts for longer distances. At present the works feed 1,200 lamps.

Electric Lighting of Railway Carriages.—The numerous disasters which take place in America owing to trains catching fire, in the event of there being a derailment or similar accident, has caused Sir Frederick Bramwell to publish a letter, in which he points out that the cause in America and Canada of the fires is to be found in the petroleum lamps usually employed in the States and in Canada for railway carriage lighting, and the subsequent ignition of the contents; and, secondly, to the scattering of the fires for the heating apparatus. The latter can be avoided by the adoption of steam heating, and the former, as Sir Frederick says, by the introduction of the incandescent electric light. The writer states that though his suggestions are obvious, he draws attention to the matter, as the remedies are not applied.

In a few days, says the *Manchester Examiner* of Tuesday, the Midland Railway Company will have ready for working two trains fitted with the electric light. It is intended that they shall run between London and Liverpool and Manchester. A further experiment will be shortly made with the light between Stockport and Manchester.

Theatre Lighting, &c.—We omitted last week to state directly, although a leaderette intimated as much, that the new Garrick Theatre has been entirely fitted throughout by Messrs. Rashleigh Phipps and Dawson, which firm has also lately completed the installation of Mr. Henry Irving's and Miss Ellen Terry's dressing rooms at the Lyceum Theatre, the Lyric Club, the late Mr. Warren de la Rue's, Mr. Peter Brotherhood's, and has just received instructions to light up Mr. Spencer Brunton's house in Suffolk, which will be a very large installation. This firm has also lately installed Baron Ferdinand de Rothschild's house in Piccadilly, and numerous other places; in fact, they are so busy that, their present premises not being sufficiently large, they will shortly move to very much more commodious ones in Berners Street, Oxford Street.

The Electric Light in Liverpool.—An application by the Liverpool Electric Supply Company, to the Health Committee of that city, for leave to lay underground wires in certain streets has been granted. The sanction of the Council was given to the proposal of the Liverpool Electric Supply Company, Limited, to make application to the Board of Trade for a Provisional Order to supply electricity "within certain defined districts." The agreement with the company provides that after the payment of seven per cent. to its shareholders any balance of interest shall be divided, half for the company and half for the easement of the rates. Permission was also accorded the Tramway Company to propel tramway carriages by means of electrical power on the Walton route, between the Old Haymarket and the city boundary.

Electric Lighting in the House of Commons.—The electric light is gradually being extended throughout the precincts of the House of Commons. It has recently taken the place of gas in the members' central lobby. Sets of ten lights now burn in each of the four corners of the hall. The electric light has been in use for some time in the library and dining-room of the House as well as in the reporters' rooms, where it is an immense benefit in keeping down the temperature, and during the recent recess a change has been made in the system in the dining room so as to diffuse the light more than before. The "Edison and Swan" lamp is that introduced in the central lobby, the "Swan" being used in some other parts of the building. The authorities are moving very cautiously. The lighting of the House itself from the roof is still supplied by gas, which is continued meantime also in the corridors and in the Ministers' rooms. There is at present about 100 horse-power; five or six times that amount will be required to light the whole building.

Electric Clocks.—The clock of the St. Stephen's Tower, Bristol, is now controlled by electricity.

The London Electric Supply Corporation.—At a recent vestry meeting at Newington, it was formally moved and carried "that no objection be offered to the draft Provisional Order lodged by the London Electric Supply Corporation, or an action taken to watch the progress of the order through Parliament.

The Electric Light in Battersea.—At a recent vestry meeting at Battersea, an opinion was expressed that at the proposed Battersea Polytechnic arrangements could be made for lighting the parish by electricity, and thus saving some £4,000 per annum. It was also proposed that an engine and dynamo be fitted at the dust destructor for lighting the parish stables.

Mr. Moulton on Electric Lighting Schemes.—Mr. Moulton, as the result of his examination and cross-examination of witnesses during the recent Board of Trade enquiry, concludes that with such a system as that of the Chelsea Electricity Supply Company, the public have almost everything in their favour, whereas he strongly condemns, from several points of view, the method of working proposed by the London Electric Supply Corporation. Probably Mr. Moulton's opinion now carries greater weight than that of any other gentleman in the legal profession when the matter under discussion relates to electricity.

Electric Lighting in Newcastle.—There are two electric lighting companies in Newcastle, and the *Daily Leader* of that town anticipates troublous times when the rivals get fairly to work. Our contemporary suggests that the proper way out of the difficulty would be for the Corporation to do the work, although such a course as this is not without its drawbacks.

Proposed Electric Lighting in Holborn District.—At the last meeting of the Holborn Board of Guardians, Messrs. Rooper & Co., on behalf of the Gwynne Electric Lighting Company, wrote asking the consent of the board to apply to the Board of Trade for a licence to supply electricity in the district. The company had engaged large premises in the neighbourhood of Leather Lane, and if they were granted a licence they would be put into working order, and thus increase both the rates and the trade of the district. On the suggestion of the chairman, the matter was referred to the Committee of Works for consideration and report.

The Electric Light at Barnet.—We are glad to see that Mr. Joel is not entirely without supporters in his endeavour to replace gas by incandescent lamps in Barnet. Mr. Thomas Parsloe writing to the *Barnet Press* of last week says :—"As to the manner in which Mr. Joel has been lighting our town, I feel it has not been so unsatisfactory as some persons have tried to prove, for as a private consumer from the first I am certain I have a better light at less cost than gas. Although some fuss has been made about some little failures, during the whole time Mr. Joel has supplied me, or agreed to do so, I have not been without the light for more than three hours altogether. I have every confidence in the light, and within a few years but few towns will be without it.

Proposed Electric Lighting in Bedford.—The town authorities of Bedford have resolved to take such steps as may be necessary to obtain powers under the Electric Lighting Act, and to engage an electrician to advise them as to the installation of the system. The Committee, after a visit to Taunton and Silvertown, appears to be much in favour of lighting Bedford electrically, and it is proposed to employ 100 arc lamps. We trust that the authorities will carry this scheme, for with such an influential townsman as Sir Henry Mance there should be no great difficulty in so doing.

Electric Light Testing at Chelmsford.—Experiments were made last week at the Arc Works with a view to giving the members of the Town Council an opportunity of choosing between two forms of lanterns. The principle test appears to have been a comparison of ordinary gas jets and incandescent lamps of 32 candle-power under the following peculiar circumstances. With gas it was impossible to tell whether a man standing on the other side of the road had whiskers or not, but when the electric lamps shed their rays upon the object all doubts were set at rest. The result was that everybody present, several gas shareholders included, admitted that the new light was, like Pears's soap, the best. Thus were the most sanguine anticipations of Councillor Albright fulfilled.

Divine Worship by Telephone.—The Tunbridge Wells Exchange of the South of England Telephone Company has been laying on divine worship to subscribers' residences by telephone. The local newspaper, the *Kent and Sussex Courier*, on the occasion of the visit of a well known Metropolitan preacher to the church which is connected with the exchange, reported the sermon through the telephone, at its office, and the transcription of the shorthand notes appeared in the ordinary course in its next issue. The chief feature in the carrying out of the scheme is the ingenious manner in which the Blake transmitters are attached to the pulpit so as to be in the most advantageous position for catching the speaker's voice and at the same time to be as little conspicuous as possible, and the success attained reflects the greatest credit on Mr. Stewart, the local engineer of the company. It is proposed to extend the system if possible to some of the other churches for the benefit of invalids and also of the patients in the hospital.

The Phonograph and Medicine.—A visit to the exhibition of Mr. Edison's marvellous phonographs in Bond Street shows very clearly, says the *Lancet*, that all musical notes can be reproduced by them with sufficient power for a fairly large audience to hear them simultaneously. It is very obvious that the exact vocalisation of a general paralytic, or anyone affected with any marked partial paralysis of the organs of speech, could be reproduced to a class, and so far this valuable invention might be utilised in medical teaching, for a faithful reproduction is in every way more suited for purposes of instruction than the most successful imitation. But this seems to be the limit of its use in medicine at present. The ticking of a watch failed to make any mark on the wax tablet, and cannot therefore yet be reproduced ; so that there is no possibility at present of storing up for all time a record of either normal or abnormal cardiac or pulmonary sounds. If this were possible, what a new era would be opened out in medical practice and science. Disputed points in rhythm would no longer be open to discussion, and explanations of many of the debatable sounds and bruits would be easily arrived at. Moreover, the exact condition of a heart or a lung at any given time could then be indelibly recorded by the organ itself, and stored up for reference at any future period, so that improvement or otherwise would pass from surmise to certainty. Is such a desideratum unattainable ?

Central Subway Bill.—The promoters of the London Central Railway Bill, which proposes the construction of a "subway" railway from Holborn to Piccadilly, having raised objections to the *locus standi* of the petitions deposited against the scheme by the Metropolitan and Metropolitan District Railway Companies, the question of the right of the companies to oppose the Bill was argued on Thursday before the Court of Referees. The Court refused to allow either company to appear in opposition against the Bill.

That Heathen Chinee!—The Chinese minister at Washington expends more money in telegram and cable despatches than the Goverment of the United States. His expenditures in telegraphing reach an average of $1,000 a week. One day recently he spent $2,000 in sending despatches to China.

Magnetic Ore Separation.—In the course of an address on "The Iron Ore Requirements of the World, and the Conditions of their Supply as Affecting the British Iron Industry," read before the British Iron Trade Association on Tuesday last, by the president, Mr. Josiah T. Smith, he incidentally pointed out that there is a probability that a good deal of the impure ores of the Lehigh Valley will be adopted for Bessemer purposes by the process of magnetic separation which is now applied to a certain extent. This process has been resorted to with a view to eliminating from impure ores the deleterious ingredients which unfit them for the production of high class metal. Mr. Smith said : "Whether the magnetic separation of iron from the materials with which it is found associated in nature is at present an assured economic success or not, so much has been actually done in this direction by Wenström and others as to justify the hope that we shall see applied to ores, *per se*, as effectual treatment with a view to getting rid of phosphorus and other metalloids as we have already seen applied to the treatment of impure iron by the basic process. We have more than passed the threshold of such a devoutly wished-for consummation, and we may well feel hopeful in reference to the future." In this connection it may be pointed out that Edison is exhibiting at the Paris Exhibition a magnetic separator in which a wholly automatic process is adopted, and the magnetic and non-magnetic particles are separated while falling in a stream from a hopper by means of powerful electro-magnets, but until we learn more concerning it we cannot give it the credit of containing any novel feature.

Electric Refining of Sugar.—This heading is old, but the subject is new. It does not refer to the American Friend swindle, which took in many unfortunate English investors whose command of loose cash was greater than their technical knowledge. Monsieur F. Baudier has taken out a French patent for an electrical process of dealing with sugar. In this case, at any rate, whether it proves a success or not, there will be data for forming an opinion as to whether the invention is practicable or the reverse.

A New Battery.—Prof. Belloni has constructed a new battery in which the two electrodes are composed of iron. It is claimed for this that its output is large, and that it is economical owing to the substitution of iron for zinc, that the sale of the bye-product of sulphate of iron is an additional saving, and that its construction is simple.

Institute of Electrical Engineers' Students' Meeting.—A meeting was held on Friday, May 3rd, Mr. Alexander Siemens in the chair. Mr. G. Müller opened a discussion on Prof. Forbes's paper on "Some European Central Lighting Stations and their Lessons." The discussion was continued by the Chairman, Messrs. W. H. Shepherd, T. L. Horn, C. H. Yeaman, and J. N. Cooper. A hearty vote of thanks to Mr. Siemens terminated the proceedings. The next meeting takes place at 4, The Sanctuary, S.W., on Friday, May 17th, at 8 p.m.

The Royal Society.—Yesterday the following papers were down for reading:—A. W. Ward, "On the Magnetic Rotation of the Plane of Polarisation of Light in Doubly Refracting Bodies;" Dr. Hopkinson, F.R.S., "Magnetic and other Properties of Iron at a High Temperature;" Dr. Gore, F.R.S., "Determining the Strength of Liquids by the Voltaic Balance."

The first *soirée* of the season was held on Wednesday evening in the Saloon of the Society at Burlington House, Prof. Stokes, the President, receiving the guests. A Gramme ring rotating under the influence of the earth's magnetism was an interesting feature in the display of scientific novelties.

Mr. Pember and the Dynamo.—Some of the legal luminaries who have been looking after the interests of the various electric lighting companies during the Board of Trade enquiry appear to possess but hazy notions of the uses to which electrical plant is put. Mr. Pember, in speaking of the accident at Deptford, which occurred at the moment Major Marindin was inspecting the station, is reported to have said he was very happy that that gentleman had not been killed, and it was certainly unfortunate that, after the inspector had been invited down, *the dynamo should seize the opportunity of blowing up.* Bravo, Mr. Pember!

Lecture.—The monthly meeting of the Ipswich Scientific Society was held on Wednesday evening, May 1st, in the small hall of the Co-operative Society, Carr Street. The President (Mr. F. Woolnough) was in the chair. Mr. W. B. Sisling, electrical engineer (local representative of Messrs. Laurence, Paris and Scott, Limited), delivered a lecture on the "Transmission of Energy by Electricity." Mr. Sisling's lecture was listened to with the greatest interest, and a hearty vote of thanks to him concluded the meeting.

The New Cable to Cape Town.—Lady Frere received on the 1st inst., from Mr. H. C. Forde, engineer for the Eastern Telegraph Company, through the new cable just laid down, the following telegram, dated from Mossamedes:—"I have pleasure in informing you that the cable from Cape Town *viâ* West Coast, about which the late Sir Bartle Frere took so much interest, is now completed."

Our Correspondence Columns.—A letter has reached us, but too late for insertion this week, on "The recalescence in the heating and cooling of steel."

Submarine Telegraph Contract (Halifax and Bermuda).—In the House of Commons on Monday last, on the motion of Mr. Jackson that the contract dated the 12th day of April, 1889, for the construction of a submarine telegraph line from Halifax, Nova Scotia, to the Island of Bermuda, be approved, Dr. Cameron said that the House had received no information about the scope of the contract, and he would ask the hon. gentleman to consent to postpone the motion, otherwise he should have to move the adjournment of the debate. The motion was then withdrawn.

A Costly Lightning Conductor.—Mr. David Tosh, of Greenock, is just completing an unusually elaborate and costly lightning conductor for the large chimney at the new works of Messrs. J. and P. Coats, of Paisley. The entire apparatus, which weighs over 11 cwt., is said to be the heaviest single conductor ever put up for a chimney. It is composed throughout of the very finest copper that can be manufactured. The band which encircles the top of the chimney, and which is 3 inches by ½-inch, is 15 feet 8 inches in circumference, and is octagonal in shape. Eight points, 30 inches in height, and tipped with platinum, are arranged around this belting. The copper conductor leading down the chimney to the ground measures 338 feet in extent, and is 2 inches wide by ¼-inch and ⅛-in. thick. A testing wire will be run from the top of the chimney to a test box on the ground. The earth plate is to expose a surface of 25 superficial feet, and be a quarter of an inch in thickness, and will weigh about 200 cwt.

Electric Cables and Subways.—At the usual weekly meeting of the London County Council, last Tuesday, at the Guildhall, under the presidency of the Earl of Rosebery, the Highways Committee submitted a report in which they stated that they had had before them a letter from the London Electric Supply Corporation, Limited, asking permission to run electric cables through the subways in Charing Cross Road, Commercial Road, Garrick Street, Northumberland Avenue, Queen Victoria Street, Southwark Street, and the Victoria Embankment. It appeared to the committee that the company had at present no statutory powers, although it was promoting a Provisional Order which was now the subject of enquiry by the Board of Trade; and, this being so, the committee had given directions that the company be informed that the Council would be unable to entertain the application for the use of the subways until the company shall have obtained the statutory powers for which it was applying. The committee's report was adopted.

A Coincidence—It is not a little curious that Dr. Lodge's paper should have been read and the discussion thereon commenced at a time when deaths from lightning have been exceptionally numerous,

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City and Guilds of London Institute Journal.—The second number of the past and present students' magazine is very entertaining, for besides Albion T. Snell's paper on the "Design of Electric Motors," it contains a considerable amount of lighter reading, Prof. Ayrton, amongst others, contributing.

Water Gas.—At the monthly meeting of the Stalybridge Corporation, the chairman of the gas committee (Alderman Atkinson) presented a very lengthy statement with reference to the last year's work in connection with the gas department of the Corporation. A good deal, he said, had been lately heard about water gas, and if all was true that was said about it, the whole of the light-producing agencies of this and every other country would be revolutionised, and both coal gas and the electric light would have to take a back seat. At present they must pause until they were posted up in the details.

The Anglo-American Brush Electric Light Corporation.—The applications for the new £75,000 6 per cent. first mortgage debentures of this company were stated to have been considerably in excess of the amount required.

Telegraph Companies as Investments.—Those who wish to invest money in cable companies should read the account given in the *Financial News* of the 3rd inst. of the Great Northern Telegraph Company of Copenhagen. According to our contemporary, the investor could desire nothing better than to know that his little all represented shares in this admirably managed and rich concern.

Medical Electricians.—With regard to the action, Moross *v.* Parkes, which we published in our last issue, with some comments, we have received two lengthy letters from medical men, in which Mr. Parkes is awarded the highest tributes to his professional abilities and character. We would gladly publish these communications, only that they do not show Mr. Moross in such a favourable light as would justify us in making them public. We are really pleased to know that Mr. Parkes is highly respected amongst those gentlemen who are best capable of judging him both professionally and socially, and it is much to be regretted that he lost his reason temporarily in his zeal to place the public on its guard. It is possible that we have not heard the last of the gentleman who has in his body a natural storage of electricity akin to the electrical eel, and which he can give off at pleasure and in any quantity, for we understand that he is announced to lecture (!) at St. James's Hall on the 12th June, when we must make special efforts to be present.

The Milky Way.—A correspondent encloses us a circular issuing from the highly genteel neighbourhood of Brompton Road, and which we are told is being widely circulated. From this we gather that electro-milk and electro-pine baths may be had at the establishment in question, and that a reduction is made on taking a quantity. We are asked to explain the nature of electro-milk, &c., but as we have never yet undergone a course of treatment at the hands of Miss Wiseman, we are quite unable to comply with our correspondent's desire. We suspect, however, that it must be closely allied to the "milk of human kindness," which one so often hears of but rarely tastes.

Dynamo Construction Patents in America.—It is said that the initial proceedings in a suit brought by the Westinghouse Electric Company, through its lessee, the United States Electric Light Company, against the Manhattan Electric Light Company, were taken on the 18th of April. The suit, presumably the first of an extensive series, is notable from the patents under which it was brought. These are two patents granted within a few days to Edward Weston, the well-known inventor, after nearly seven years' delay caused by interference proceedings. If they prove to be valid, they will be among the most valuable patents extant in the class of dynamo-electric machinery. The feature of construction covered by them is the building up of an armature core from iron discs, with interposed plates of insulating material. Four carefully worded claims, undoubtedly the broader from the early date of application, when the field was unnarrowed by similar inventions, cover, as far as can be seen, the whole system of disc-built armatures. It is nearly certain that much litigation is in prospect over these two Weston patents.

Tramway Traction.—M. de Lindheim, of Vienna, who has been going very fully into the tramway and railway statistics of Europe, has come to the conclusion that electric traction is the best system. Taking 1 as representing the cost of electric traction, he represents horse traction as costing 1·47.

Electricity and the Eiffel Tower.—On May 1st the raising of the electric lighthouse to the top of the Eiffel Tower was effected. This is similar in every respect to the most powerful of the lighthouses on the coast of France. One peculiarity is that the lantern is furnished with three coloured lenses, blue, white and red, so that it is the national colours which will slowly make the tour of the cupola. The lighthouse cannot be seen from the Exhibition, as it is only at about 1,500 mètres that it can be observed. On May 4th there were placed in position two electric projectors which from the Eiffel Tower will throw their powerful rays of light over Paris. Each of these projectors is not less than 90 centimètres in diameter. Placed at 290 mètres near M. Eiffel's rooms, below the lighthouse, they will in clear weather show at a distance of about 10 kilomètres. They are identical to those in use in the ironclads of the French navy. Their luminous power is equal to 10,000 carcels, and the total intensity of their luminous rays equals 8,000,000 carcels. By concentrating the two projectors on the same object, an intensity of 15,000,000 to 16,000,000 carcels could be obtained.

Electricity at the New Paris Railway Terminus Hotel.—This hotel has been built facing the St. Lazare Station, and in communication with it specially in view of the Exhibition. In fitting the building electricity has been laid under contribution to distribute the correct St. Lazare Station time and also for lighting. The whole of the bells will also be sounded by electricity; and lastly, every one staying at the hotel will have in his room a telephone by means of which he will be secured attendance without the slightest delay.

Congrès International des Electriciens. — This congress is arranged to be held in Paris for eight days, from the 24th to the 31st of August. It will practically be a continuation of the work of the Congress held in 1881. The subjects of most importance to be discussed are: "The practical measurement of electrical energy of all kinds;" "The measurement of current in absolute value, with the means of easily reproducing the same;" "Electrical counters for continuous and alternating currents;" "The practical measurement of lighting;" "Definition of the constants of a machine from a commercial point of view," &c. The programme consists of six sections, devoted, respectively, to "Measurements," "Induction Machines, Transformers, Distribution," "Electro-Chemistry," "Lighting," "Telegraphy," "Telephony," "Various Applications," "Electro-Physiology." M. Mascart will be the President.

Sad End of an Electrician.—Late on Thursday night, May 2nd, Constable Osborne, of Kentish Town, heard the report of firearms at 56, Leverton Street, Kentish Town, and on entering he found Charles John Simmons, an electrician, lying in the passage bleeding profusely from the mouth. A doctor was called for, but on his arrival he pronounced life extinct. The deceased, who had been in a despondent mood for some time past, had shot himself in the mouth with a revolver, the bullet lodging in the brain.

Electrical Company.—The Belgian company concerned in the Seel patents has been converted into a limited company, under the title of the Société Anonyme Belgique pour la Fabrication de lampes Electriques à Incandescence, with a capital of 500,000 francs (£20,000).

Electrical Society.—The Electrotechnische Verein, of Prague, which was founded on the 17th March, 1888, under the presidency of Professor Puluj, has issued its first annual report, from which it appears that there are now 66 members, and that 14 papers have been read before it.

Aluminium.—On Friday evening last Sir Henry Roscoe delivered a lecture at the Royal Institution of Great Britain on "Aluminium," a title which would lead people to expect a general treatment of the subject. This, however, was not Sir Henry's method of dealing with it, for he contented himself with pointing out the enormous price formerly charged for aluminium, which was prohibitive, and the fact that it had now, by the improved process of production, been brought down to such a rate as made it an industrial metal. He then described its manufacture by the Castner process, and the audience, unless they knew otherwise, would certainly have been led to the conclusion that the Castner process was the only one by which aluminium could be produced on a large scale. There was not even the slightest hint given that there were such things in existence as the Cowles or Heroult electrical processes, to say nothing of others which have also proved to have merits.

Manufacture of Submarine Cables in Italy.—Messrs. Pirelli & Co., of Milan, started a couple of years ago the first submarine cable manufactory in Italy. These works now occupy 8,000 square metres of the foreshore of the Gulf of Spezzia, and employ 100 hands, with a capacity for turning out 10,000 metres per day. We have already touched upon the cables laid by this firm, which has a particularly good record.

Tramways.—One of the most recent stock-broking circulars in recommending investment in tramway shares as likely to rise, says: "Lastly, but not least, mechanical traction by electricity is now within the region of practical politics, and its effect upon net earnings may be such as will double the dividend paying capacity of all tramway properties." The wording of the statement is not quite as good as it might be, but we reproduce it as showing which way the wind blows.

A Gas Company Sat Upon.—The Geneva Gas Company has taken legal proceedings against the municipality of that town owing to the introduction there of the electric light on the plea that their concession gave a monopoly of lighting. The case was decided against the company, and on appeal this decision has now been confirmed.

Contract Open.—The town of Craiova, in Roumania, intends to adopt electric street lighting, tenders for which will be accepted up to the 13th June, addressed to the Bureau Technique de la Mairie, and accompanied with £200 caution money. Firms tendering are required to state what system they propose to employ, the price per lamp, and the number of years for which they demand the concession.

Lighting of Cuzac.—There will be used two Gramme dynamos of 90 ampères and 135 volts for the lighting of Cuzac, France. There will be 300 lamps of 10 and 16 C.P. There will also be 112 accumulators, capable in case of breakdown of supplying all the lamps for two hours, or 50 lamps of 16 C.P. for 50 lamps. The town lighting will consist of 50 lamps of 16 C.P., and 10 lamps of 10 C.P.; the rest will be private lights. A concession for 20 years has been given to M. Can.

A Big Order.—The Ball Engine Company, of Erie, Pa., has received from the Edison Electric Illuminating Company, of Brooklyn, an order for twelve 300 horse-power compound engines. With one exception, this is said to be the largest order ever given in America for compound engines, and it will take about a year to fill it. The output of these shops for February was 18 engines, aggregating 1,570 horse-power, divided as follows:—Three 150 horse-power, four 100 horse-power, six 80, three 60, one of 35, and one of 25. It is expected that this summer will be one of the busiest the concern has ever seen.

Electric Lighting of the Municipal Theatre, Magdeburg.—This theatre, which was formerly lighted by gas, consumed annually about 63,000 cubic metres of gas. The house is now mainly lighted electrically. Power is supplied from two 40-H.P., one 5-H.P., and one 2-H.P. gas engines. Three Edison type dynamos of 240, 240, and 30 ampères and 105 volts, are employed. These have been supplied by the Electricitäts-Gesellschaft, of Berlin. The machine room is situated in the northern veranda of the theatre. There are 75 10-C.P., 433 16-C.P., 347 25-C.P., and 160 32-C.P. glow lamps, making a total of 1,015 lamps. The orchestra is still lighted by gas, and in the lobbies the electric light, gas, and oil are used to ensure safety. The installation has been at work for some considerable time without the slightest hitch, and the light has given general satisfaction.

The Electric Light in Paris.—The Municipal Council has given a decision in the case of three applications for concessions for laying electric light mains in the districts on the right hand side of the river. Two have been rejected as not complying with the rules laid down, and the third has been accepted with some modifications. In the last case Messrs. Nouvelle and Geisenberger proposed to light the districts lying between the Seine and the ramparts on the right of the river, which includes the Rue du Bac, in which there is a large number of shops. The Council has decided: (1) That Messrs. Nouvelle and Geisenberger are authorised to lay mains within certain limits described. (2) That the concession be annulled if the firm do not deposit the caution money within a month. (3) The concession is granted conditionally on the firm also undertaking to light on the left hand bank of the river, the districts between the Rue du Cherche-Midi, the quays, the Esplanade, the Boulevard des Invalides, and the Boulevard Montparnasse. (4) The caution money is fixed at £12,000. The Prefect of the Seine has submitted to the Municipal Council a plan prepared by the municipal engineers, in view of the electric lighting of the Halles Centrales and neighbourhood, as regards the laying of mains. Tenders have been accepted from Monsieur Papin and from Messrs. J. Carré and Fils.

Telephony in Austria-Hungary.—The Minister of Communications at Buda-Pesth has accepted the proposal of the Austrian Minister of commerce to establish direct telephonic communication between Vienna and Pesth. Work will be commenced shortly. The Mayor and various delegates of the Chamber of Commerce of Pilsen have interviewed the Austrian Minister of Commerce with a view to obtaining a telephone line between Pilsen and Vienna, or at least to Prague. In reply, the Minister stated that he cannot promise anything for this year, but that the proposal will be carried out in 1889. The Chambers of Commerce of Trieste and Fiume have likewise petitioned for telephonic communication between these two towns. In the meantime Trieste will be connected with Laibach, and in the event of the experiment proving a success, telephonic connection will next be established between Trieste, Gratz and Vienna.

Personal.—Mr. R. D. Smillie, member of the Institution of Electrical Engineers, who, for the better part of half a dozen years, has been in charge of all the electric lighting installations that have been fitted into ocean-going steamers built and equipped by Messrs. Denny, of Leven Shipyard, Dumbarton, who were the first shipbuilding firm in that part of the country to carry out electric light equipments themselves, is about to start on business on his own account in Glasgow. His successor as electrical engineer to Messrs. Denny is to be Mr. Alfred Mavor, who has had an extensive and most valuable experience in connection with the electric lighting of the Forth Bridge, where such lighting is no longer necessary.

Electric Light for London.—The *Lancet*, in a leader upon this subject, says :—The battle is chiefly between the two types which are known as the alternating current or transformer system on the one hand, and the continuous current (with or without storage batteries, but usually with) on the other. The alternating current cannot be used to charge storage batteries, and for a very similar reason it has not yet been turned to any useful account as motive power. The difficulty of making these swift and antagonistic currents co-operate efficiently has hitherto baffled the ingenuity of mechanicians. These are serious drawbacks from the consumer's point of view. He never can be for a single moment independent of the generating engine ; if that fails for a moment, he will be plunged in instantaneous darkness. Then, again, those thousand-and-one conveniences which arise from making electricity play the part of the household drudge are denied to the users of the alternating current. But, on the other hand, it is possible to use these swiftly alternating currents at very much higher tension than anyone would propose to employ in a current not subject to rapid reversals, and thereby to secure great economy in the distributing mains. Thus in all the schemes now before Major Marindin the continuous current is intended to be distributed at comparatively low pressure, not exceeding 100 or 110 volts. The shock from such a current would be perfectly harmless if by any accident it were passed through the human frame. The alternating currents, on the contrary, are to be distributed at pressures varying from 2,000 to 2,500 volts, and the effect of "short-circuiting" any appreciable current of this intensity through one's person would unquestionably be disastrous. Of course, precautions will be taken to prevent any passage of a current of this intensity into the lamp circuit, and the "transformer," from which the system has received a name, will reduce it to the safer voltage at which the ordinary electric lamp is run. But there is at least some ground for the uneasiness which one of its critics has expressed at the idea of "2,500 volts grumbling in the cellar." Shortly the case may be put thus : electric current on the one system is distinctly better to have, but on the other system much easier to get. We hope that in the granting of provisional orders the Board of Trade will recognise the essentially experimental character of the present step, and take care that Londoners get a fair opportunity of testing every form of electrical supply.

Electrical Progress in the States.—The marvellous activity which exists in the electrical world is shown, says the *Western Electrician*, by the fact that on April 9th, 53 patents relating to electrical inventions were granted.

The Electrical Power Storage Company.—Mr. J. Irving Courtenay, the managing director of this company, communicated the following to the *Times* of May 4th :—"In your issue of this day a statement is attributed to the counsel for the London Electric Supply Corporation to the effect that the Electrical Power Storage Company had 'no capital subscribed or paid up.' This is not only absolutely incorrect, but is a very serious mis-statement, calculated to do great damage to the Electrical Power Storage Company. That company has been carrying on business in the United Kingdom and throughout the world since 1882 ; in fact, it was doing business years before any of the other companies appearing at the Board of Trade local enquiry were incorporated, including the London Electric Supply Corporation. The number of our shareholders is 511, and the authorised capital is £200,000, of which £149,450 is issued and fully paid up. I must therefore request you to be good enough to insert this correction in your next issue."

Submarine Telephony.—A submarine telephone cable, about 30 miles long, is to be laid between Buenos Ayres and Montevideo.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Edison Gower-Bell Telephone Company of Europe, Limited.—The annual return of this company, made up to the 19th ult., was filed on the 23rd ult. The nominal capital is £500,000 in £1 shares. 385,009 shares are taken up, of which 370,000 are considered as fully paid. £15,005 has been received in respect of 15,009 shares, £4 remaining unpaid.

Midland Electric Light and Power Company, Limited.—The annual return of this company, made up to the 20th March, was filed on the 25th ult. The nominal capital is £50,000 in £10 shares. 2,231 shares are taken up, and of these 2,224 are considered as fully paid. The full amount has been paid upon the remaining 7 shares.

Foreign Pilsen Electric Light and Power Company, Limited,—The annual return of this company, made up the 19th ult., was filed on the 26th ult. The nominal capital is £30,000 in £1 shares. 29,800 shares are issued, the whole of which are credited as fully paid.

Mining and General Electric Lamp Company, Limited.—The statutory return of this company, made up to the 20th ult., was filed on the 26th ult. The nominal capital is £100,000 in £1 shares. 55,885 shares are taken up, 28,190 being considered as fully paid. The full amount has been called upon the remaining shares, the calls paid amounting to £27,445, and unpaid to £250. Registered office, 11, Abchurch Lane, E.C.

Woodhouse and Rawson, Limited.—An agreement of the 26th ult., filed 29th ult., cites that Messrs. Otway E. Woodhouse and F. L. Rawson formed a combination or syndicate for developing and acquiring the Schulke lamp patents, that said F. L. Rawson invested £1,600 therein, and that he has acquired the interests of Wm. Tice and J. Stewart Wallace in the said combination. The company undertakes to issue to the said F. L. Rawson 500 fully paid ordinary shares, in full satisfaction of all claim and demand by him for repayment of the said sum of £1,600 so invested in consideration of acquiring his interest in said combination.

CITY NOTES, REPORTS, MEETINGS, &c.

West India and Panama Telegraph Company, Limited.

THE twenty-fourth ordinary general meeting of this company was held at Winchester House, Old Broad Street, on Wednesday, May 8th, when the chairman of the company (Mr. C. W. Earle) presided.

The secretary, Mr. R. T. Brown, read the notice convening the meeting; and after the minutes of the previous general meeting had been read and passed,

The Chairman moved the adoption of the report and accounts, which he presumed might be taken as read, and said that when he addressed the shareholders on the last occasion he drew attention to the fact that the half-year's account then under consideration was the best since the corresponding half-year of 1883. On the present occasion there was an improvement over the corresponding period of 1887 of about £1,600, although in 1887 there were advantages in the hire of ships which did not arise in 1888. The improvement was partly accounted for by an increase of traffic of £1,050; but there was a set-off against that by way of the expense incurred in the repairs of cables, amounting to £8,402, as compared with the expenditure in the corresponding period of over £12,000, and that was the main cause of the improvement in the half-year under report. The average expenditure for the last nine half-years for repairs and renewal of cable was about £5,000 more than it had been in the last half-year, a point to which he drew particular attention, because sometimes when there was a good half-year it was made use of for the purpose of advocating various claims for dividing the reserve fund and so leading people to suppose that all difficulties and troubles had passed away and that they were about to enter into a time of great prosperity. But telegraph cables were very uncertain in their breaking down, and the low expenditure of one half year did not encourage the feeling that the same good luck would follow in the future. For the past five half years a small increase in traffic had taken place, which showed that there was probably some development going on in the West Indies; but the records of periods further back showed what falls and bounds the traffic returns were exposed to, and, though the great fall in 1885 of £7,000 had now been nearly

recovered, he was not disposed to be too sanguine about any great development of the traffic having occurred. The traffic fluctuated according to the condition of the sugar industries, which were exposed to influences of various natures. The French Cable Company had started, but so far its opposition had not been very much felt. The danger of such an organisation was the temptation to go to places already served by the older company; but when they considered the smallness of the traffic to be obtained, one could only feel that the new comers only entered into the speculation with the idea of serving the glory of their country, or of giving a slight blow to other interests. The French people readily put down their five-franc pieces for such purposes with great alacrity, and the part of the French cable going through the Caribbean Sea was a source of anxiety to the English company. It did not do to prophesy in regard to future prospects, but he believed that the first half-year in 1889 would see the company through the arrears on the first preference shares, to a certainty; they would then commence paying off the arrears on the second preference shares, and, if all went well, in a couple of years they would be quite free from all those liabilities, and the ordinary shareholders would then begin to receive some payment. He concluded by formally moving the adoption of the report.

Mr. W. Ford seconded the resolution.

Mr. Fitzgerald noticed that the amount set down for the reserve fund had decreased from £3,000 to £1,000 in the last three half years, and that that fund now amounted to about £134,000, and he asked whether the interest on that sum, with the £1,000 put down in the last half year, might be taken as the future amount to be added to the fund. He also pointed out the heavy cost of keeping two cable ships, and asked if one cable ship was not sufficient, especially seeing the large proportion of time that neither ship was on the field of operations.

Mr. Guesdon said that the amount payable to the preference shareholders was £23,540, and out of the profits of the year 1888, no less than £41,475 was paid, the difference of £17,935 having gone towards arrears. In the course of two years all the arrears would be paid off, and there would then be some £18,000 available from that source for dividends, which, with the amount previously put to reserve fund, would, in 1891, provide sufficient to pay the ordinary shareholders as much as 3 per cent. He asked if something could not be given in the meantime. He considered the present reserve fund sufficiently safe for all ordinary purposes.

Sir G. Chambers was not quite so much a pessimist as the chairman, he said, with reference to the future of the West Indies, as there were circumstances occurring, particularly with reference to the sugar interest; but seeing the possibility of competition on the part of France, he held it to be a matter of the highest importance that the reserve fund should be strong.

Mr. Russell said that £900 a year would have been saved had the debentures been sold out at the premium obtainable, instead of renewing them at 5 per cent. in place of the former 6 per cent.

The Chairman said that for a long time the company had only one ship, and it was with considerable heart tearing that a second was agreed to. If things could be depended upon to continue as they had done in the last two half years one ship would do, but if cables broke and were unrepaired, not only was traffic lost, but the subsidies were suspended also. Cables sometimes went all at once, and on one occasion 11 were down at the same time. For those reasons a second ship was a necessity, and he could hold out no hopes of doing without it, as there were many complicated questions to consider in connection with it. For many years the reserve fund was very much in arrear of what it ought to be to provide for the depreciation that was calculated upon the life of cables, and it had to be brought up. It was at present about level. The cables had had 19 years' life, and calculations showed that the reserve fund now set aside was in proportion. The reserve fund was a depreciation fund which ought, in the time given as the life of a cable, say 30 years, in meal or malt, in cable or cash, to enable the company to be in a position to renew the whole of the cables at the end of that period. The profit made upon the reinvestment was about £13,000, but whether the board would consider it prudent to deal with that or any part of it in the shape of dividends had not been discussed. The reserve fund could not be drawn upon for paying off the debentures.

The motion was put and carried unanimously.

The retiring directors, Mr. Henry Holmes and Mr. H. Weaver, were re-elected.

The auditor, Mr. J. G. Griffith, was reappointed.

A vote of thanks to and confidence in the chairman and directors was heartily accorded, and the meeting terminated.

The Brazilian Submarine Telegraph Company, Limited.

THE thirty-first ordinary general meeting of this company was held at Winchester House on the 8th inst., Sir James Anderson being in the chair.

Mr. R. Collett, the secretary, read the notice convening the meeting, and the report, which was published in the REVIEW for May 3rd, was taken as read.

The Chairman, in moving the adoption of the report, remarked that there had been an increase in the revenue for the half-year ending December 31st last of over £30,000, as compared with the revenue for the corresponding period of 1887. The expenses had increased by some £2,000, which mainly arose from their depreciating the value of the cable in stock. A saving of £400 had been effected in the working expenses in England and at the stations. A reduced tariff to Madeira, St. Vincent, and Pernambuco had come into effect on May 1st., 1889, but there had not been sufficient time to judge of the effect of the reduction. The company had been unfortunate in the interruption of the Western and Brazilian system and of the Government land lines, but they expected the interruptions to be removed and the lines restored for traffic within 48 hours. A joint purse arrangement had been made with the African Direct, the Eastern, and South African Companies. The company had £75,000 invested in the African Direct Company. He formally moved the adoption of the report.

Mr. F. Yule seconded the motion, which was carried unanimously.

Some discussion took place as to the reduction of tariff, which was objected to by Mr. Newman.

Mr. Griffith thought that the unclaimed dividend and interest account should be extinguished by putting it to the shareholders account.

The Chairman said that experience showed those closely engaged in working telegraph lines that low tariffs would be forced on to them if they did not reduce the rates gradually when they could afford to do so. No doubt a person who paid 6s. for a message would be ready to pay 7s., but reductions gave an impulse to the traffic, which would not be otherwise experienced. They must study their customers and the public, otherwise they would have opposition which would be deserved.

A vote of thanks to the chairman and directors closed the proceedings.

Newcastle Electric Supply Company, Limited.

ON Monday the statutory first general meeting of this company was held at its offices, 1, St. Nicholas's Buildings, Newcastle, Ald. T. G. Gibson in the chair.

The Chairman explained that the consent of the Newcastle-upon-Tyne Corporation had been obtained to the company's license, and that the company's license had been favourably considered by the Board of Trade, who had intimated that it would be granted at the end of the statutory period. The chairman further stated that a site had been acquired for the company's works, tenders for buildings accepted, and plant ordered and in course of construction.

The directors were reappointed with important additions, and a vote of thanks to the chairman closed the proceedings.

The Western and Brazilian Telegraph Company, Limited.—At a meeting of the board of directors of this company, held on May 2nd, after placing £7,000 to renewal fund and £6,400 to debenture redemption fund, and writing off the rebate on issue of debentures, viz., £26,100, it was decided to recommend at the forthcoming meeting of the company that a dividend of 9s. per share (free of income tax) be paid. This dividend, with the interim one already paid in November last, makes a total distribution for the past year of 5 per cent. per annum as compared with 4½ per cent. for the year 1887.

The South of England Telephone Company.—At their meeting to-day, the directors of this company declared a dividend of 6 per cent. per annum on the preference shares for the half year ending April 30th.

The Electrical Power Storage Company, Limited.—A meeting of this company was held yesterday at Winchester House, at 12.30 p.m. As the meeting was said to be private, and as our reporter was consequently refused admission, we are unable to give a report of the proceedings.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ended April 26th, amounted to £3,200.

The Cuba Submarine Telegraph Company, Limited. The estimated traffic receipts for the month of April were £4,000 as compared with £3,705 in the corresponding month of last year. The receipts for the month of January, estimated at £5,100, realised £3,221.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of April were £1,867, against £1,800 in the corresponding period of last year.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of April, 1889, amounted to £42,709, as against £37,351 in the corresponding month of 1888.

The Eastern Telegraph Company, Limited. The receipts for the month of April, 1889, amounted to £51,432, against £51,562 for the corresponding month of last year, or a decrease of £130.

The Great Northern Telegraph Company, Limited. The receipts in April, 1889, £21,000; January 1st to April 30th, 1889, £84,000; corresponding months, 1888, £85,200; and of 1887, £81,530.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 26th, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,009.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending April 30th were £8,125.

ACCIDENTS TO AERIAL TELEGRAPH LINES IN 1887.

A selection (from the Berne "Journal Télégraphique" of April 25th) of those countries in which the greater number of accidents appear to have occurred.

Countries.	Total length of Wire, Kilometres.	Total number of Poles.	Total number of Insulators.	Accidents to Poles.		Accidents to Wires.		Accidents to Insulators.	
				Lightning.	Other causes.	Breakage.	Contacts, earth, &c.	Lightning.	Other causes.
Austria	103,438	711,644	2,680,648	826	...	650	878	4?9	...
Belgium	29,505	87,178	471,626	16	1964	1080	1208	20	4556
Dutch East Indies	8,648	116,966	155,638	135	5511	84	402	790	2383
France, Corsica, Tunis, Algeria	270,989	1,661,551	4,157,889	1085	757	1254	5957	1157	2422
French Indo-China	6,037	27,011	43,475	935	545	153	242	788	60
Germany	278,783	1,372,997	5,614,535	858	208	1300	3972	125	1711
Holland	17,121	69,774	252,321	29	5887	143	767	41	4069
Hungary	...	...	...	348	262	907	3548	1337	564
Italy	113,046	458,752	1,582,644	957	110	730	2965	659	672
Roumania	9,932	96,804	205,268	79	79	263	423	331	6021
Russia	211,058	...	...	395	3121	3301	1703	231	506

AMERICAN NOTES.

By DAS TELEPHON.

AN opinion of great importance to foreign inventors who may desire to procure patents, or file caveats therefor in the United States, was given by Attorney-General Miller at the request of the Commissioner of Patents. As this opinion will govern the action of the U. S. Patent Office, I send it to the REVIEW.

"*Defects in the Patents' Treaty.*—Washington, *April 15th.*—Attorney-General Miller has submitted an important opinion upon the question of the construction of the articles of the international convention proclaimed at Berne, July 7th, 1887, having for its object 'The protection of industrial property in relation to patent caveats.' The treaty provides in general that the subjects or citizens of each of the contracting governments shall enjoy in all the other countries parties to the convention the same advantages that the respective laws thereof accord to its subjects or citizens so far as concerns patents for inventions, trade and commercial marks, and the commercial name. An examination of the convention shows that the peculiar features of the American patent system were unfortunately not considered in framing it, and hence, while as between the citizens of the different nations of Europe, whose patent systems are closely allied, it may be advantageous, citizens of the United States have found no benefit from it in securing patents for their inventions in Europe, and aliens found no benefit from it in protecting their inventions in the United States. The privilege of filing a caveat for an uncompleted invention is one of the peculiar features of the American system, and by the terms of the law is confined strictly to citizens of the United States and to foreigners who have resided one year in the country, and made oath of their intention to become a citizen. The Attorney-General holds, substantially, that the treaty is a reciprocal one, each party to its covenants to grant in future to the subjects and citizens of the other parties certain special rights to its subjects and citizens. It is a contract operative in future inter-territorially. It is, therefore, not self-executing, but requires legislation to render it effective for the modification of existing laws."

New York, *April 16th.*—The city officials began the work of cutting down the telegraph poles on Broadway this morning, and went at it with a will. One effect will be to cut off all electric light illumination for some time, until the companies get their wires into the conduits.

New York, *April 17th.*—To-night and last night the part of the city about Union and Madison Squares, that usually teems with light and life as soon as the sun goes down, was as dark and cheerless as a country town where the lamps are not lit except when the moon does not appear. It was one of the results of the raid on the overhead electric wires. But the city will stand for a while, confident that the companies will not be long in coming round to a compliance with the law and a regaining of their old-time income.

The fact is, the putting of the wires underground in the so-called electrical subways is purely what is well known here as a "*job*"—under a law enacted by the Legislature of New York under *peculiar* circumstances—those *peculiar* circumstances being that an "electrical subway company" *procured* the law to be passed, under which *all* the wires, either for electric light, telegraph, or telephone, should be put into subways to be constructed by that company, and that the company should receive an exorbitant compensation for the use of their subways. The Legislators, in their *wisdom*, decided to reverse and annul all laws governing the flow and action of electrical currents, and to enact that there should not be any induction between neighbouring wires.

These "Notes" have recorded several instances of explosions in the manholes of the subway, and the Board of Electrical Control have lately submitted a report on the cause of these explosions, of which the following is the substance:—"It was shown that the explosions were due to gas from leaking pipes penetrating the soil and entering the subways and manholes of the Electrical Subway Company. An astonishing amount of gas was shown to be contained in the soil underlying the older parts of the city, and to exclude it from the subways was found to be almost impossible. Blowing machines had been used with good results to clear the subways. Explosions occurred mostly at the manholes, and were of great violence. The ignition of the mixture of air and gas in them was not traced to its cause in every instance, but sparks from the shoe of a passing horse, discarded cigar stumps or matches, and lights in houses near by were thought to be the causes in many cases."

Bids for street lighting by electricity have been made in response to advertisements for proposals. The Brush Company bid 35 cents per lamp per night.

Not Complimentary to the Electric Motor.—John Dorsey, by William A. Hammond, his attorney, entered suit in the Court of Common Pleas yesterday against the Baltimore and Hampden Passenger Railroad for $5,000. Mr. Dorsey claims that on or about May 6th, 1886, the company negligently and carelessly ran a "certain unusual, improper, ugly, and dangerous-looking engine called an electric motor," which caused a pair of horses he was driving to run away, he himself being thrown to the ground and greatly injured.

I hear from the *highest* authority that the U.S. Government are in possession of an instrument made exactly after a description found in a book published in English in 1868, which resembles the box transmitter of P. Reis, and which instrument acts as a *microphone*, and that by it electrical impulses are transmitted so that a telephone receiver constructed after the description published by C. Bourseul in 1854, reports clearly and distinctly and sufficiently loud any word and sentence said with the transmitter, this instrument the Government intends to use in the suit against the Bell Company in Boston.

Baltimore, *April 19th*, 1889.

ELECTRIC LIGHTING AT THE MELBOURNE CENTENNIAL EXHIBITION.

WE have received the account of the close of the very successful Exhibition at Melbourne, in Victoria, and as part of its great success appears to have been due to the admirable way in which the electric lighting of it was carried out, we print the account of it which we have received from the secretary of the Australasian Electric Light, Power and Storage Company:—

The very short time allowed for the execution of the contract added materially to the contractors' difficulties and expenses; but notwithstanding all obstacles, the lights were in operation on the opening night, and were well maintained until the close of the Exhibition, the number being constantly increased as fresh demands were made on the installation. The Exhibition was formally opened on August 1st, but the contract was not signed until March 27th, and the special annexe for the engines and dynamos was not ready until long after the date expected; while the month of July was more than half over before the painting of inside was finished sufficiently to allow the cables and leads to be joined up to the dynamos and switchboard.

When the lighting of the Exhibition was first discussed the question arose as to whether gas or electric light should be adopted. As concerned the picture galleries, there could be of course no question at all, as the sole condition on which many of the pictures were allowed to be exhibited at night was that they were not to be exposed to the fumes of gas.

Mr. K. L. Murray, of the Railway Department, who had extensive experience of lighting by gas and by electricity, was requested by the Commissioners to report on the matter, and his estimate, although made in November, 1887, was, as the figures which we give will show, wonderfully near the amount of lighting that was

actually required. He estimated for 950 arc lights of 1,000 candle-power each, and for about 50,000 C.P. other lighting, making a total of about 1,000,000 C.P.

In Mr. Murray's report he stated that he considered it fair to compare gas and electric lighting at per candle-power; and doubtless many good reasons can be advanced for taking this as a fair ratio of comparison in a place like an exhibition, and for the following reasons:—Firstly, as regards the portion lighted by arc lamps, the experience gained in the best lighted modern exhibitions proves that not less than 1 candle-power must be allowed for each 1 to 1½ square feet of floor surface if the building is to appear bright, cheerful, and attractive at night, or in other words, that one must allow from ·66 to 1 candle-power for every square foot of floor space. This proportion was confirmed by experience at the Adelaide Exhibition, at which it was found that, although 1 C.P. per 1·44 square feet gave a good light when the space was open and the colouring of the locality light, yet the same amount of C.P. produced but a gloomy effect among crowded show-cases and where the surroundings were of a dark tone. In adopting the above figure as the limit of proportion, it must distinctly be borne in mind that, although 1 C.P. per square foot of floor surface, or even more, may be provided by the installation, it by no means follows that there will be 1 C.P. of light per square foot *on the floor* of a building, as much of the light goes sideways and upwards; but unless the stated volume of light was there, the gloominess of the building would prevent a large attendance of the public.

Mr. Murray's estimate assumed the use of burners consuming 5 cubic feet of gas per hour with gas at 5s. 9d. per 1,000 feet, and that each of them would give 20 C.P. Only best gas and Argand burners would yield such an average, whereas in the Centennial Exhibition the bat's-wing or fish-tail burners must have been employed. Gas is, however, 5s. 4d. per 1,000 feet in Melbourne now, and, although it was dearer when the Exhibition started, it may be taken for granted that an average of 16 C.P. for a 5 feet burner with Melbourne gas is a liberal allowance even when the pipes keep clear, which rarely happens for any length of time. Now, the total area to be illuminated in this case by arc lamps was 1,142,821 square feet, and to light this area 915 such lamps were used with actual illuminating power of 924,009 candles; consequently the average area illuminated by each lamp was 1,249·9 square feet of floor space, or ·808 C.P. per square foot.

To give the same amount of light by gas would have required about 58,000 No. 5 burners with their numerous adjuncts, which would consume 290,000 cubic feet of gas per hour at 5s. 4d. per 1,000 feet, or at a cost of about £78 per hour. The expense of fitting up this mode of lighting would have been heavy; but against that may be set the cost of the special building erected for the electric dynamos, engines, &c. The accounts are not yet closed, but the latest available printed figures reveal that the cost of the whole of the installation plant, including incandescence dynamos and all accessories, has been £60,000. As the special building is set off against gas pipes and fittings which would afterwards be almost valueless, the whole of the plant is saleable; but allowing 50 per cent. for depreciation and other contingencies, it is found that the use of the electric plant has necessitated an expenditure of £30,000, exclusive of six months interest at 5 per cent., to which must be added the cost of 26 weeks of working. The correctness of the figures cannot absolutely be vouched for, but an amount of £300, it is believed, will give a little over the actual cost of the fuel, wages, carbons, &c., for arc lighting.

We thus have the following results:—

Nett cost of plant	£30,750
Cost of working for 26 weeks at £300 per week ...	7,800
Actual cost of electric arc lighting	£38,550

In these figures the arc lighting is considerably handicapped by including the cost of the incandescence plant, which means engines, dynamos, and lamps nightly supplying 44,112 C.P. = 2,757 other No. 5 gas-burners in situations where gas would be intolerable.

There were 160 nights of lighting (783¼ hours); consequently the nightly average was 4·89 hours, which, at £78 per hour, gives £331 per night, or £53,429 for the term of the Exhibition, as the gas bill for those portions lighted by arc light, showing a clear saving of £15,000 in favour of the electric light. The volume of heat which so many gas-jets would have emitted would have been enormous; and both the picture galleries and the concert hall would have been intolerably close if gas had been used.

Mr. K. L. Murray drew up the specifications, and to the constant and careful supervision by himself, and by his assistant Mr. W. Stone, much of the success of the scheme is due.

Tenders were originally put in by the Australian Electric Company, Melbourne, as agents for the "Australasian Electric Light, Power and Storage Company, London," carrying on business in these colonies.

Captain F. C. Rowan, general manager of the Australasian Company, assisted by Mr. R. E. Fletcher as chief engineer, prepared the estimates and ordered the plant. The latter was nearly all supplied by the Anglo-American Brush Corporation, and all parties concerned in the enterprise deserve great praise for the rapidity and completeness with which this, the largest and most important electric light installation yet carried out, was placed in good working order and successfully maintained, despite the unlucky accident to the R.M.S. *Garonne*, while on her way out with a large portion of the plant, which compelled the contractors to work, for some time, both night and day, and involved a serious charge for overtime.

The following statistics in this connection will be of interest:—

Total area of buildings lighted by arc lamps ...	1,142,821 sq. ft.
Total area of buildings lighted by incandescence lamps	163,906 „
No. of Brush arc lamps used in building ...	908
No. of Brush arc lamps used outside of building	29 ... 937
No. of Brockie Pell arc lamps used	5
Total number of arc lamps	942
No. of Edison-Swan incandescence lamps, 16 C.P.	1882
No. of Sunbeam incandescence lamps of 200, 300, 400, 500, and 600 C.P.	27
Total C.P. of arc lamps	953,000
Total C.P. of incandescence lamps	44,112
Average area of floor space per arc lamp (915 lamps) inside lighting	1249·9 sq. ft.
Average area of floor space per incandescence lamp	85·9 „
Candle-power per sq. ft. of floor space (arc lights) inside lighting	·808 C.P.
Candle-power per sq. ft. of floor space (incandescence) inside lighting	·268 „
Total No. of hours lighting	783¼ hours.
Average No. of hours per night (160 nights) ...	4·89 „
Total No. of watts used by arc lamps inside lighting—447,696 do., outside lighting—14,123	461,819
Watts per sq. ft. of floor space (inside lighting)	·391
Total No. of watts used by incandescence lamps —1882—16 C.P. 64 watts = 120,448 watts 27 sunbeam = 24,295 watts	144,743
Watts per sq. ft. of floor space	883
Area of concert hall...	19,000 sq. ft.
Candle-power of incandescence lamps in concert hall	·578 C.P. per „
Circuits (arc)—No. of arc circuits	41
Average length of circuits	1·22 miles.
Total amount of cable used	50 „
Incandescence—No. of incandescence circuits ...	7
Amount of main cable used	3 miles 981 yards.
Amount of Brush mains and leads to arc lamps	10 miles.
Total amount of cable and wires used for arc and incandescence circuits...	63 miles 981 yds.
Total weight of copper in above	17 tons 11 cwt. 1 qr. 19 lbs.
Dynamos (arc)—1 No. 8 L Brush dynamo, 55 lamps	27,500 watts.
40 No. 7 L Brush dynamos, 24 lamps = 12,000 × 40	480,000 „
1 No. 6 Brush dynamo, 10 lamps	5,000 „
Total capacity or out-put available from arc dynamos (= 1,025 Brush lamps)	515,200 „
Incandescence—7 No. E. 2 Victoria dynamos, 110 volts, 210 ampères	23,100 „
Total capacity of above machines in 16 C.P. 64 watts lamps	2,526 lamps.
Belting—Lancashire patent woven belt	3,452 feet.

Shafting.—Total length, 203 feet. Diameter, 7¼ to 6¼ inches. Supported on 33 iron pedestals. Divided into three sections, with clutch couplings, but always run connected as one length. Fitted with 52 pairs of cast iron pulleys (one fast and one loose of each pair), for driving the arc and incandescence dynamos. Normal speed of shafting, 192 revolutions per minute.

Engines.—Three pairs of horizontal high pressure engines, of Marshall and Sons type, with automatic expansion gear. Each pair fitted with a cast iron flywheel, 12 feet diameter, weighing 19 tons, and having 13 grooves on face for 13 = 4½-inch manilla ropes, 12 robes used for driving on to countershaft. Diameter of cylinders, 20 inches. Length of stroke, 40 inches. Normal speed, 60 revolutions per minute, but worked up to 80 revolutions. Normal S.H.P. of each pair, 500 H.P.

Boilers.—Twelve boilers of the Cornish multitubular type, 16 feet 9 inches in length by 5 feet 9 inches in diameter, furnace tubes 10 feet 10 inches in length by 3 feet 3 inches in diameter, and 148 tubes 2 inches outside diameter and 5 feet 11 inches in length. Each boiler provided with cylindrical steam chamber on top, and the whole covered with wrought iron casing, forming a portion of the flues, and acting as a super-heater for the steam. All boilers fitted with double safety valves of the Ramsbottom type, 3 inches in diameter, and the usual gauge glasses, blow-off cocks, &c., and rest in cast iron saddles; the lower and unprotected portions of the boilers are covered with a non-conducting heat composition. The boilers are arranged in two groups of eight and four, and are in separate houses. They are all connected to one common steam main, each boiler being provided with a steam stop-valve, to disconnect from the main, if required. Working pressure, 120 lbs. per square inch.

Six-inch Blake's donkey pumps and 6-inch Gresham's patent improved Gifford's injectors supplied the water to the boilers, after passing the water through 6 feed-water heaters, which raised its temperature to 170° and 180° Fah.

Three wrought iron smoke stacks, 3 feet 9 inches diameter, carried away the smoke, of which, however, there was very little, as the fuel consisted of coke, with a very small quantity of coal mixed with it.

Boiler houses, engine and dynamo room were all under one

roof, the boiler houses being separated from the engine and dynamo room by brick walls.

Total length of dynamo room, 221 feet. Total width of dynamo room, 142 feet 6 inches, less 47 feet 6 inches occupied by engines and boilers.

Arrangements of Dynamos and Circuits.—The dynamos were arranged in two parallel rows on each side of the countershafting, which was in the centre of the room.

The arc dynamos were connected to a switchboard of simple construction, to which also all the ends of the various lamp circuits were connected. By this arrangement any dynamo could be put on to any lamp circuit as desired.

The lamp circuits were arranged so that in every court in the vast building the lamps lighting a particular court were supplied with current from separate dynamos, which prevented the possibility of any part of the building being left in darkness, should any mishap occur with the machinery.

The incandescence dynamos were connected to a very elaborate and handsome switchboard, by means of which all the dynamos could be joined up in what is technically known as parallel, that is, all the dynamos could be arranged so as to give their current into one common main. The advantage of this arrangement is, that all the machines became practically one large dynamo, built up of seven distinct parts, any one of which can be removed from the circuit should occasion arise, the remaining dynamos taking up the extra work of the machine removed.

AN ELECTRIC RAILWAY IN SCOTLAND.

A SCOTCH correspondent sends us the following interesting item :—

Mr. Monteith, of Carstairs House, has made a most interesting experiment in the application of electricity to railway locomotion. He has had electric lighting introduced into his residence; and having the installation at hand he conceived the idea of constructing an electric railway between the house and Carstairs Station. Under his personal superintendence the undertaking has been completed in a workmanlike manner. Under his active direction, too, the car for the conveyance of passengers, and the conducting and insulating material, have been constructed. The work is so far advanced that last week a demonstration was given of the success and practical utility of the experiment. The railway is a mile and a quarter in length. It has a gauge of 30 inches, and following a winding course, passes through some of the best scenery. While most of the road is comparatively level, there are several gradients, the steepest being 1 in 75. The railway is intended to supersede carting and carriage work between the house and the station, and there is a siding running into the Caledonian Railway for the accommodation of goods and coal traffic. A four-wheeled car for the passenger traffic has been constructed specially for high speed, and when completed it will present a neat and compact appearance. The 8 H.P. motor, which has been specially designed for the purpose, is fixed underneath the car, between the two axles, and is designed on the ordinary Gramme principle, the shape being specially adapted for the car. The motion is communicated to the driving wheels by a chain passing round a tooth wheel on the motor and a larger wheel on the axle. A cone friction gearing, which has yet to be added to the machine, will permit of full speed being more quickly attained; and by reversing this gearing an attachment will be introduced to vary the speed of the car, and enable it to take steep gradients easily. The electric current is generated by a dynamo driven by a turbine wheel situated at the Cleghorn Falls on the Mouse three miles distant from Carstairs House. The wires from the dynamo are carried overhead on ordinary telegraph poles to within 200 yards of the house, and thence are taken underground, enclosed in lead pipes, to the switchboard near the battery in the basement of the house, a few yards from the terminus of the railway. A battery of 106 E.P.S. cells is used for lighting the house, and the current for working the railway or producing the electric light in the house can be taken either from the battery or direct from the dynamo. On each side of the railway is an iron conductor carried on insulators, and the current is conveyed into the motor by rubbing contacts, the brushes being fixed on each side of the car. While the power available for the motor is 10 horse, force equal to only 4 horse has as yet been tried, but even with that a speed of 35 miles an hour has easily been attained. It has been calculated that the electricity needed to drive the car is equal to that required for 40 incandescent lamps. The car has been in use for the last couple of days, and everything has worked smoothly, no hitch having occurred. In the numerous trips made to the station and back, the working of the car was in the highest degree satisfactory. As soon as the electric circuit is completed by the contact of the brushes with the electric conductors the car starts off at a rattling pace, which exceeded 20 miles an hour. While, as had been said, Mr. Monteith himself designed the car, the electrical and mechanical part of the work has been done by Messrs. Anderson and Munro, electrical engineers, Glasgow, and in the work of superintendence Mr. Monteith has had the assistance of Mr. David Hunter. This is said to be the first permanent electric railway in Scotland. The line will be formally opened in a few weeks.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

"On Lightning, Lightning Conductors, and Lightning Protectors." By Dr. OLIVER LODGE, F.R.S., member.

(*Concluded from page* 432.)

Summary of Points of Difference and Controversy.

39. It may be convenient here to summarise a few of the points wherein the doctrines which I advocate differ from the views held by the older electricians. And the summary will give me an opportunity of emphasising the incorrectness of the older views in many instances.

I quote a few statements, prefixed by capital letters, from an abstract I made for the *Electrician* after the Bath meeting of the British Association. (See *Electrician*, September 21st and 28th, 1888.)

A. Rods as at present constructed, though frequently successful, may and do sometimes fail, even though their earth is thoroughly good; the reason being that they offer to a flash a much greater obstruction—a much worse path—than is usually supposed: an obstruction to be reckoned in hundreds or thousands of ohms, even for a very thick copper rod. N.B.—This is not resistance proper, but impedance.

I may be permitted here to repudiate the doctrine which has several times been attributed to me since the Bath meeting, that it is safest to be without lightning conductors altogether. The long experience of persons learned in this art is by no means to be despised, and until an agreement as to improvements has been arrived at the safest plan for ordinary persons is to adhere to existing practice. Nevertheless, that conductors sometimes fail is as certain as that they often succeed. My statement is that customary arrangements are not perfect, and are susceptible of improvement. The statement of the Lightning Rod Conference is that "there is no authentic case on record where a properly constructed conductor failed to do its duty." Mr. Preece calls the statement "most decisive." It is certainly *decided*, and in the light of other matter contained in the same red covers I assert it to be in its natural and intended signification decidedly false. The only signification which makes it true makes it also senseless; as if one should record the statement that white things are white. In my Society of Arts lectures I said nothing against the report of the Lightning Rod Conference, because the work done by that body, in collecting information, abstracting papers, and recording instances was obviously very valuable, and much of the report itself is correct; while as for the occasional rash statements in that document I imagined the signatories would wish them to sink into oblivion in silence. But Mr. Preece has revivified them, and conspicuously made himself afresh responsible for them;* accordingly, I now extract one or two more sufficiently dogmatic and unfortunate statements from the same source:—

"A man may with perfect impunity clasp a copper rod an inch in diameter, the bottom of which is well connected with moist earth, while the top of it receives a violent flash of lightning." "If all these conditions be fulfilled, if the point be high enough to be the most salient feature of the building, no matter from what direction the storm may come, be of ample dimensions, and in thoroughly perfect electrical connection with the earth, the edifice, with all it contains, will be safe, and the conductor might even be surrounded by gunpowder in the heaviest storm without risk or danger." To adhere to such a view as this now, with tenacity sufficient to cause it to be promulgated as an authoritative scientific statement, would be, in my opinion, little less than criminal.

"All accidents may be said to be due to a neglect of these simple elementary principles." Certainly, this "*may be said*," because it already has been said over and over again; but it cannot be said with truth.

Whenever an accident happens, a believer in the modern exponents of the Lightning rod Conference who could not point out a flaw, or a bad joint, or a bad earth; or a possible flaw, or a possible bad joint, or a possible bad earth; would feel himself disgraced as a practical man. An instance occurred in quite a recent number of *Nature*. The writer of "Electrical Notes" records that a number of fish had been killed in a pond into which the earth end of a conductor had been led, and concludes with the ejaculation, "When will people learn to make proper earth connections?" I select this instance as typical of the extraordinarily contradictory advice often bestowed on that long-suffering body the British public. Before an accident, the pond would be pointed out as an excellent earth, as indeed it most likely was. After the slaughter of the fish, the erector of the conductor is impersonally ridiculed for having utilised it. So with any struck building. After an accident defects *must* be forthcoming, because else there would be "an authentic case on record where a properly constructed conductor failed to do its duty," which *ex hypothesi* is absurd and impossible; therefore it was not constructed in accordance with the directions of the Lightning Rod Conference. Q.E.D.

* Saying at Bath, as a prelude to a question from the Report, "The Report itself is most decisive and most important; there is a true ring about it—the ring of men who knew what they had done and what they were writing about."

B. When a Leyden jar is charged it corresponds to a bent spring, and its discharge corresponds to the release of the spring. Its discharge current alternates, therefore, in the same way and for much the same reason as a twitched reed or tuning fork vibrates. The vibrations decay in either case because of frictional heat production, and because of the emission of waves into the surrounding medium. A single spark of a Leyden jar, examined in an exceedingly fast revolving mirror, is visibly drawn out into a close succession of oppositely-directed discharges, although its whole duration is so excessively minute.

It is very likely that this statement will now no longer be denied. So I pass to the next.

C. A lightning flash is a spark between cloud and earth, which are two oppositely electrified flat surfaces, and the flash corresponds therefore to the internal sparking between the two plates of a great air condenser. All the conditions which apply to a Leyden jar under these circumstances are liable to be true for lightning. Sometimes the resistance met with, either in the cloud itself or in the discharger, may be so great that the spark ceases to be oscillatory, and degenerates into a fizz or rapid leak; but there can be no guarantee that it shall always take this easily manageable form; and it is necessary in erecting protectors to be prepared for the worst and most dangerous form of sudden discharge. The apparent duration of a lightning flash is due to its frequently multiple character, and indicates successive discharges, not one long-drawn-out one. Nothing that lightning has been found to do disproves its oscillatory character; because Leyden jar discharges, which are certainly oscillatory, can do precisely the same.

This was in answer to Mr. Preece's contention that lightning could not be oscillatory, because it magnetised steel bars and deflected ships' compasses. The next is an antidote to the continually made statement that the one thing needful for an efficient lightning conductor is *conductivity*.

D. Although some conductivity is necessary for a lightning conductor, its amount is of far less consequence than might be expected. The obstruction met with by an alternating or rapidly varying discharge depends much more on electro-magnetic inertia or self-induction than upon common resistance. So much obstruction is due to this inertia, that a trifle more or less of frictional resistance, in addition, matters practically not at all. It is very desirable to have a good and deep earth in order to protect foundations and gas and water mains from damage, and in order to keep total impedance as low as possible.

I find it sometimes thought that I have argued against the need of a good earth. This is not so. I have argued against the exclusive and exaggerated attention that has been paid to this need.

In opposition to the following statements, *e, f, g, h, i*, the substance of which may be considered as hitherto orthodox, I make the statements subsequent, labelled *E, F, G, H, I*:—

e. No danger is to be feared from a lightning conductor if only it be well earthed and be sufficiently massive not to be melted by a discharge. All masses of metal should be connected to it, that they may be electrically drained to earth.

f. The shape of the sectional area of a conductor is quite immaterial; its carrying power has nothing to do with extent of surface; nothing matters in the rod itself but sectional area or weight per foot run, and conductivity.

g. Points, if sharp, should constitute so great a protection that violent flashes to them ought never to occur.

h. Lightning conductors, if frequently tested for continuity and low resistance by ordinary galvanic currents, are bound to carry off any charge likely to strike them, and are absolutely to be depended upon. The *easiest* path protects all other possible paths.

i. A certain space contiguous to a lightning rod is completely protected by it, so that if the rod be raised high enough a building in this protected region is perfectly safe.

These statements I say are erroneous. The following I believe to be correct:—

E. The obstruction offered by a lightning rod to a discharge being so great, and the current passing through it at the instant of a flash being enormous, a very high difference of potential exists between every point of the conductor and the earth, however well the two are connected; hence the neighbourhood of a lightning conductor is always dangerous during a storm, and great circumspection must be exercised as to what metallic conductors are wittingly or unwittingly brought near or into contact with it. When a building is struck, the oscillations and surgings all through its neighbourhood are so violent that every piece of metal is liable to give off sparks, and gas may be lighted even in neighbouring houses. If one end of a rain-water gutter is attached to a struck lightning conductor, the other end is almost certain to spit off a long spark, unless it also is metallically connected. Electric charges splash about in a struck mass of metal, as does the sea during an earthquake or when a mountain top drops into it.* Even a small spark near combustible substances is to be dreaded.

F. The electrical disturbance is conveyed to a conductor through the ether or space surrounding it; expressed more simply, lightning currents make use of the periphery of a conductor only, and so the more surface it exposes the better. Better than a single rod or tape is a number of separate lengths of wire, each thick enough not to be easily melted, and well separated so as not to interfere with each other by mutual induction.

The liability of rods to be melted by a flash can be easily overestimated. A rod usually fails by reason of its inertia-like obstruction, and consequent inability to carry off the charge without spittings and side flashes; it very seldom fails by reason of being melted. In cases where a thin wire has got melted, the energy has been largely dissipated in the effort, and it has acted as an efficient protector, though, of course, for that time only. Large sectional area offers very little advantage over moderately small sectional area, such as No. 5 B.W.G.

G. Points, if numerous enough, serve a very useful purpose in neutralising the charge of a thunder-cloud hovering over them, and thus often prevent a flash; but there are occasions, easily imitated in the laboratory, when they are of no avail; for instance, when one upper cloud sparks into a lower one, which then suddenly overflows to earth. In the case of these sudden rushes, there is no time for a path to be prepared by induction, no time for points to exert any protective influence, and points then get struck by a violent flash just as if they were knobs. Discharges of this kind are the only ones likely to occur during a violent shower, because all leisurely effects would be neutralised by the rain-drops better than by an infinitude of points.

H. The path chosen by a galvanic current is no secure indication of the course which will be taken by a lightning flash. The course of a trickle down a hill-side does not determine the path of an avalanche. Lightning will not select the easiest path alone; it can distribute itself among any number of possible paths, and can make paths for itself. Ordinary testing of conductors is therefore no guarantee of safety, and may be misleading. At the same time, it is quite right to have some system of testing and of inspection, else rust and building alterations may render any protector useless.

I. There is no space near a rod which can be definitely styled an area of protection, for it is possible to receive violent sparks or shocks from the conductor itself; not to speak of the innumerable secondary discharges which, by reason of the electro-kinetic momentum and of induction, and of the curious recently discovered effect of the ultra-violet light of a spark, are liable to occur as secondary effects in the wake of the main flash.

Instructive Extracts from Reports of Damage by Lightning.

40. Reading between the lines of existing reports on damage done, one can frequently find evidence of many of the phenomena to which I have now called attention. Of course they are not recorded in any prominent manner, because they are to the observers ill-understood and puzzling facts; it is very difficult to note what has exactly happened in any given case unless some clue or expectation has been formed beforehand. The bad conductivity clue, which was the only one prominently available to the skilled recorders in the following cases, is a very partial one, and in many cases is quite insufficient to account for the facts without undue pressure being put upon it.

Under such circumstances the record of the facts is of course far more valuable than the comments made upon that record; and in the following extracts the theoretical remarks should be eliminated or slurred over.

One minor imperfection, common to many accounts, is that they are not sufficiently alive to the possibility of all manner of branching discharges: so that the discharge is said to leave a conductor and go to something else, when the truer statement would be that some *portion* of it branched off at such and such a point.

In the following quotations the references are usually to the pages of the volume of the Lightning Rod Conference, published by Spon in 1882:—

41. Illustrating side flashes and surging circuits.

"*L.R.C.*, p. 39.—*J. Murgatroyd. St. Mary's, Crumpsall, near Manchester.*—A lightning conductor from spire touched the eaves gutter, and a gas pipe touched the end of this gutter. The lightning passed from the conductor along the gutter to the gas pipe, melted it, and set the church on fire by igniting the gas."

"*L.R.C.*, p. 39.—*Wyatt Papworth.*—Tall spire struck. The church stands in an open position with no large trees near. It was provided with an iron lightning conductor ¾ in. diam., fixed with iron holdfasts, and carried down inside the spire and tower into ground; the top of it was said to be attached to a bold copper finial on the spire about 150 feet from the ground, and 50 feet above ridge of roof; the lightning is supposed to have first struck the finial, it slightly deranged some beds of masonry in upper part of spire, then descended by iron rod to belfry, melted a gas tube in the floor, and set fire to the belfry by igniting the gas."

From Abstract of Report on the Destruction by Lightning of a Gunpowder Store at Bruntcliffe, Yorkshire. By Major V. D. Majendie, R.A. (*L.R.C.*, p. 77.)

"The gunpowder exploded at 4.30 p.m. on August 6th, 1878, during the greatest intensity of a violent thunderstorm. The building was brick, with brick arched roof, length 9 feet, width 5 feet, height 6 feet (internal dimensions). The store had a uniform thickness of three bricks, and was furnished at one end with an iron door, at the other end with a lightning conductor. The conductor consisted of a copper wire rope, 10 gauge copper wire, the rope being $\frac{1}{16}$th inch thick, having four points at the top (one large one in the centre, and three smaller ones round it); it extended to about 13 feet above the top of the building, and about the same length was carried into the ground and terminated in a drain. The conductor had been erected in 1876 by Mr. John Bisby, of Leeds, and was fixed to a pole distant about 2 inches from the end of the building opposite to that in which the iron door was fixed (it was not connected with the iron door in any way). No one was near the store when the powder exploded, and it seems probable that [the earth connection of the conductor was

* See the Report of the Krakatoa Committee.

bad] the mass of iron in the door offered at least an equally good path—and that the gunpowder was ignited by a flash passing between the two imperfect conductors."

To make this report more completely scientific, it would be well to omit the words I have put in square brackets.

Extract from a reply of Mr. Baldwin Latham, C.E. :—

"It is no uncommon thing for buildings provided with what are called lightning conductors to be damaged by lightning, and the cause is due to the inadequacy of the conductor to carry the electric fluid, which will leave the conductor for a better or a larger conductor." (See also sec. 43.)

42. As illustrating that a good conductor affords no absolute security, the following document is worthy of reproduction in full, as given in *L.R.C.*, p. 115 :—

"*Ueber Blitzableiter und Blitzschläge in Gebäude welche mit Blitzableitern versehen waren. Von G. Karsten. Keil.* 8vo. 1887. *(Abstracted by R. Van der Broek.)*

"In this pamphlet Dr. Karsten gives an account of two cases in which buildings that were provided with lighting conductors were damaged by lightning. The author states that the statistics for the year 1873 show that in Schleswig-Holstein 26 per cent. of all the cases of fire were caused by lightning; $\frac{1}{10}$th part of these cases occurred in the towns and the remainder in the country.

"Do lightning conductors guarantee absolute protection? The author answers this question as follows:—There is no absolute certainty in empirical matters; each new case may direct our attention to circumstances that have been overlooked. If lightning conductors cannot be said to ensure perfect safety, they certainly afford a very high degree of protection.

"The flash of lightning which struck the church at Garding, on the 18th of May, 1877, fractured the conductor in 15 places, and pierced the wall of the steeple in two places. The inefficiency of the conductor resulted from the carelessness with which it was fixed; the line was laid down the north side of the steeple, and fastened with 25 wall eyes; these wall eyes were hammered too deep into the wall, thus damaging the line and forming a short and sharp bend in each case, besides also unduly straining the wire. The damage to the steeple was the consequence of a neglected secondary circuit. There are an excessively large number of tie-rods in the steeple; the heads of these rods are not connected together, neither are they, except in one case, in close proximity to any of the larger masses of metal that are about the building. The conductor passed close to one of those heads; the south side of the steeple, where the opposite head is, becoming wet through the rain, a secondary circuit was formed, and a return shock followed; the damage to the steeple was trifling.

"The rod was provided with a conical point, rather blunt, but surmounted by a short platinum point. The copper line-wire was of good material—not of a uniform thickness, but at the weakest places not weighing less than 240 grammes per lineal metre (8 oz. per yard, or rather less than ¼-inch diameter, if solid). The earth plate was sunk into a well 10 metres deep, and tested faultless after the discharge."

43. The following series of notes are better not separated, though they bear upon different points :—

L.R.C., p. 93 *et seq.*—*From Abstract of Statistics of Buildings and Ships struck by Lightning. By F. Duprez, Member of the Academy.*

Illustrating occult dangers from secondary disturbances in the neighbourhood of conductors.—"The author cites three cases of buildings set on fire though protected by lightning rods. But the precise cause of the fire was not ascertained."

Illustrating multiple flashes.—"In each of two cases the lightning struck at once the three rods fixed to a building."

Illustrating that a poor earth is not necessarily fatal to the efficiency of the conductor, except as to the protection of the soil itself and of things buried in it.—"Out of fifteen cases of lightning rods struck, in which the conductors were simply buried more or less in the soil, they carried off the strokes in eleven without the buildings being injured, or any trace being left of it, except that the ground was upheaved where the latter was too dry."

Illustrating a matter important, if true; suggested by Professor Fitzgerald theoretically at Bath; not yet verified by me.—"In two cases the stroke broke the conductor at points where its direction was abruptly changed."

Illustrating side-flash.—"In two other cases the lightning left the conductors struck, and fell upon buildings near, without causing damage to those on which the rods were fixed."

Illustrating brush discharges from conductor, and surging circuits its neighbourhood.—"Two electrical phenomena are to be noted as sometimes occurring when a lightning rod is struck. First, when a conductor is formed of metallic plates, a peculiar noise is heard like water pouring on a fire. Second (independently of the form of the conductor), electric sparks are emitted from bodies near. The author cites examples at Berne, 1815."

44. The following illustrates the carrying power of fairly thin wire, and the fact that thin wires may protect, although themselves deflagrated. *From Mr. Preece's paper on "Lightning" to Society of Telegraph Engineers, November*, 1872 (*L.R.C.*, p. 101):—"There were only two cases in the past season when his wires (No. 8 iron, 0·17 in. diam.) were absolutely fused."

From letter by Admiral Sullivan (*L.R.C.*, p. 195) :—"You will like to know a case in which a copper wire acted as a perfect conductor, *though fused throughout its length*. It was at Monte Video, in the house of the English Consul, a flagstaff was struck, and conducted the lightning through a flat roof near the bell wire of a suite of rooms (the wire ran in sight near the cornice) through a hole in each dividing wall, and then down to the bell in the basement. The wire was melted into drops like shot, which burnt a row of small holes in the carpet of each room. A dark mark on the cornice above showed where the wire had been. At the bell there was a slight explosion and some little damage, but I do not recollect whether anything acted partially as a conductor from that point, and so carried off that part of the charge.

"This, I think, shows that even an ordinary bell wire will act as a conductor for a rather strong stroke of lightning, as the large flagstaff was shattered."

45. As illustrating that experience has led to the perception of the value of large surface to a rod, I may quote the standard American work, Spang's "Practical Treatise on Lightning Conductors." Philadelphia, 1887 (*L.R.C.*, p. 113) :—

"A conductor of large surface exercises a much greater protective action than the same quality of metal in the form of a wire or solid rod.

"Not because electricity in motion resides on the surface, but that the expansive action of a discharge may have a wider scope through the metal."

[The incoherence of the reason does not destroy the correctness of the stated fact.]

Messrs. D. Munson & Co., of Indianapolis, Indiana, have sent me specimens of their rods, which have flanges and sharp edges, and in various ways aim at large surface. Their rods are composed of copper and iron mixed, which is curious, and their mode of attainment of large surface is needlessly complex.

The following illustrates the contradictory views about manner of conduction by lightning rods. *Letter from Admiral Sullivan* (*L.R.C.*, p. 199) :—

"I firmly believe in the surface theory of Harris. I had been with him often when he made experiments nearly fifty years since, and witnessed a strip of tinfoil of the thinnest kind, and about ¼ inch wide, protect a model mast of about 6 inches in diameter from electric shock, that without it split the mast to pieces, aided by a small hole through its centre filled with gunpowder. And I always thought that the surface conducting theory of Harris was indisputable. But about twenty years since, having to approve a proposal of the Trinity House for a new conductor of a lighthouse, which, like previous ones, was an inch in diameter copper rod, called 'Faraday's Plan,' I thought I would go up to the Royal Institution and ask him why he did not use a copper tube instead, giving much greater conducting power with less copper. I did so, and he asserted positively that the conducting power depended entirely on the volume of copper in the section of the conductor, no matter whether it was in a bolt, plates, or tube; and that if Harris said differently, 'he knows nothing whatever about it;' of course I approved the rod-conductor. But singularly enough, though I had not seen Harris for years, he came to town a few days after, and came to the Board of Trade to see me, and bring me a piece of his large tube conductor, with a connection that he was fitting to the Houses of Parliament. When I told him what Faraday's opinion was, he answered, 'Then he knows nothing about it.'"

46. I may call attention to some apparently sound doctrines in a paper by Capt. Bucknill, R.E., abstracted in *L.R.C.*, p. 242.

That lightning can penetrate into collieries is proved by an account of a meeting of Mining Engineers (*L.R.C.*, p. 237).

The same sort of thing is illustrated by the accident at Bootham Bar, York (*L.R.C.*, p. 219), when the lightning struck down into a cavity surrounded by high buildings with lead roofs, iron rain-water pipe, and an iron portcullis, to get at a street bracket 11 feet 6 inches above the pavement, melting its pipe, and setting a house on fire by the large flame produced (*L.R.C.*, p. 219).

47. That the existence of gas pipes make houses more difficult to protect, and in fact causes dwelling-houses to require almost as much attention as powder magazines, can be illustrated by a good number of extracts. The following may serve (*L.R.C.*, p. 239) :—

"On July 13th, 1880, during a thunderstorm, the large 400-light gas-meter of this mill, though locked up in a cellar, and with no light near it, exploded, and the gas, which is supplied through a 4 inch main, was ignited. This was repaired, but on July 5th, 1881, during another thunderstorm, precisely the same accident occurred."

From an interesting report, signed J. Gavey, on damage to a church at Cardiff (*L.R.C.*, p. 218), I make the following extract :—

"On examining more closely the surroundings of the lightning conductor, I observed that the church gas pipe, an iron one, about 1¼ inches in diameter, passed through the wall of the building about 6 feet from the conductor, and was carried in a direction corresponding with the hole caused by the explosion (see plan). I immediately concluded that this explosion was due to the current breaking across from the conductor to the gas pipe, and on opening up the hole I found this to be the fact. The conductor crossed the gas pipe at nearly a right angle, being about a foot above it. The under portion of the conductor bore evident marks of fusion, and, more interesting still, the gas pipe was slightly coated with a very thin deposit of copper, so thin that it perished in my attempt to remove it; but still there was an undoubted coating at one spot."

Continuing the account of this kind of damage, the following interesting remarks by Prof. Kirchhoff have a bearing on the important practical question whether gas-pipes should or should not be utilised for earth; but their main utility lies in the proof afforded of the unique kind of danger which gas-pipes introduce :—

Injury to Gas and Water Pipes by Lightning.

The city gas company of Berlin, having expressed the fear that gas-pipes may be injured by lightning passing down a rod that is connected with the pipes, Professor Kirchhoff has published the following reply:—

"As the erection of lightning-rods is older than the system of gas and water-pipes as they now exist in nearly all large cities, we find scarcely anything in early literature in regard to connecting the earth end of lightning-rods with these metallic pipes, and in modern times most manufacturers of lightning-rods, when putting them up, pay no attention to pipes in or near the building that is to be protected." Kirchhoff is of the opinion, supported by the views of a series of professional authorities, that the frequent recent cases of injury from lightning to buildings that had been protected for years by their rods, are due to a neglect of these large masses of metal. The Nicolai Church, in Griefswald, has been frequently struck by lightning, but was protected from injury by its rods. In 1876, however, lightning struck the tower and set it on fire. A few weeks before, the church had had gas-pipes put in it. No one seems to have thought that the new masses of metal which had been brought into the church could have any effect on the course of the lighting, otherwise the lightning-rods would have been connected with the gas-pipes, or the earth connection been prolonged to proximity with the pipe. A similar circumstance occurred in the Nicolai Church in Stralsund. The lightning destroyed the rod in many places, although it received several strokes in 1856, and conducted them safely to the earth. Here, too, the cause of injury was in the neglect of the gas-pipes, which were first laid in the neighbourhood of the church in 1856, shortly before the lightning struck it. The injury done to the school-house in Elmshorn, in 1876, and to the St. Lawrence's Church, at Itzehoe, in 1877, both buildings being provided with rods, could have been avoided if the rods had been connected with the adjacent gas-pipes.

"If it were possible," says Kirchhoff, "to make the earth connection so large that the resistance which the electric current meets with when it leaves the metallic conducting surface of the rod to enter the moist earth, or earth water, would be zero, then it would be unnecessary to connect the rods with the gas and water pipes. We are not able, even at immense expense, to make the earth connections so large as to compete with the conducting power of metallic gas and water pipes, the total length of which is frequently many miles, and the surface in contact with the moist earth is thousands of square miles. Hence the electric current prefers for its discharge the extensive net of the system of pipes to that of the earth connection of the rods, and this alone is the cause of the lightning leaving its own conductor."

[This, like many another theoretical remark, is not to be supposed true.—O.J.L.]

Regarding the fear that gas and water-pipes could be injured, he further says: "I know of no case where lightning has destroyed a gas or water-pipe which was connected with the lightning-rod, but I do know cases already in which the pipes were destroyed by lightning because they were not connected with it. In May, 1809, lightning struck the rod on Count von Seefeld's castle, and sprang from it to a small water-pipe, which was about 80 metres from the end of the rod, and burst it. Another case happened in Basel, July 9, 1849. In a violent shower one stroke of lightning followed the rod on a house down into the earth, then jumped from it to a city water-pipe, a metre distant, made of cast iron. It destroyed several lengths of pipe, which were packed at the joints with pitch and hemp. A third case, which was related to me by Professor Helmholtz, occurred last year at Gratz. Then, too, the lightning left the rod and sprang over to the city gas-pipes; even a gas explosion is said to have resulted. In all three cases the rods were not connected with the pipes. If they had been connected the mechanical effect of lightning on the metallic pipes would have been null in the first and third cases, and in the second the damage would have been slight. If the water-pipes in Basel had been joined with lead instead of pitch, no mechanical effect could have been produced. The mechanical effect of an electrical discharge is greatest where the electric fluid springs from one body to another. The wider this jump the more powerful is the mechanical effect. The electrical discharge of a thunder cloud upon the point of a lightning rod may melt or bend it, while the rod itself remains uninjured. If the conductor, however, is insufficient to receive and carry off the charge of electricity, it will leap from the conductor to another body. Where the lightning leaves the conductor, its mechanical effect is again exerted, so that the rod is torn, melted, or bent. So, too, is that spot of the body on which it leaps. In the examples above given it was a lead pipe in the first place, a gas pipe in the last place, to which the lightning leaped when it left the rod, and which were destroyed. Such injuries to water and gas pipes near lightning rods must certainly be quite frequent. It would be desirable to bring them to light, so as to obtain proof that it is more advantageous, both for the rods and the building which it protects, as well as for the gas and water pipes, to have both intimately connected. Finally, I would mention two cases of lightning striking rods closely united with the gas and water pipes. The first happened in Düsseldorf, July 23rd, 1878, on the new Art Academy; the other August 19th, last year, at Steglitz. In both cases the lightning rod, the buildings, and the pipes were uninjured."—*Deutschen Bauzeitung*. (Quoted in the *Building News*, September 10th, 1880.)

48. That lightning sometimes does things which is on the hitherto available views inexplicable, is evidenced by the following record by one who, of all others, made lightning conductors his hobby, who acquired an immense amount of experience concerning them, and to whom the carrying out of probably the most perfect system of protection in actual use is largely due. I mean the late M. Melsens:—

Note on the Lightning Flash at Antwerp Railway Station, July 10th, 1865. By M. Melsens.

"I have described this lightning stroke, which was very harmless, since all the damage was confined to the breaking of a square of glass in the roof of the covered station of the railway at Antwerp; but in connection with it I found myself confronted by so extraordinary a phenomenon that I had to search through all the descriptions of lightning strokes which might offer a certain analogy to this with which I have to do. It was only on looking through my notes again, and returning several times to the place, that I have ventured to describe this very extraordinary stroke, and I have only published it after a long time, when it seemed to me that I could establish it upon careful observations and experiments which seemed of a nature to corroborate my conclusions. Mention made of 19 lightning flashes, which present some analogy to that which struck Antwerp Station:—

"A few words are sufficient to show the peculiarity of the phenomenon. The lightning crossed a square of glass and produced in it a hole similar to that which would be produced by a projectile thrown upwards from below at a slow rate, say, from 30 to 50 metres per second, and travelling from earth towards the sky; the edges of the hole were melted. I have given a description of the experiments I made, together with Ruhmkorff, to prove that in reality lightning does travel from the earth towards the sky; the proof which I give of it seems to me decisive.

"The extraordinary fact, as I have remarked, is to see the lightning pass, by means of a very bad conductor, through a square of glass 4 millimetres in thickness, forming a parallelogram of $0^{m}.35 \times 0^{m}.38$, having angles of 83° and 97°.

"The opening produced was, at a distance of some centimetres from iron and lead conductors, in perfect metallic communication with all the iron of the station. The weight of this latter exceeds 120 tons. But the anomaly does not stop there: in effect, to the right and left of the glass roof in which the broken pane was, the covered platform of the station has a roof of zinc No. 13, presenting to the lightning a surface of 3,000 square yards; the weight of the zinc is not less than 15 tons; the three tall rods of the lightning conductor are in immediate metallic contact with this zinc, and with the conductor, and the whole is connected to 28 hollow columns, serving to carry off rain water. The collection of these metals would allow one to suppose that they were arranged well enough to carry off lightning or any such disturbance easily; but in this instance it despised them, and chose a path entirely unexpected. Let me add that there was a shed some 62 metres from the station built on hollow columns and iron framework, and the greater part of it roofed with zinc; moreover, about 40 metres on the opposite side were mere sheds roofed with zinc; the metallic surface was not less than 2,000 square metres. Moreover, in my investigation, I might mention plenty of other metals in communication more or less perfect with the earth, grids, sconces, gas pipes, telegraph wires, rails, &c. Besides, the whole of the platform may be considered as one large lightning conductor in perfect communication with a very damp earth, and offering hardly any resistance to the passage of the current from the building.

49. Of all the buildings in the world not wholly made of metal, the Hôtel de Ville at Brussels was and is the most perfectly and elaborately protected. No electrician exists but would a year ago have asserted, had they gone over it, that it was absurdly and exaggeratedly safe from damage by lightning. In June it was struck and set on fire.

The case has been investigated and published in the *Bulletin de la Société Belge d'Electriciens*, for September and October, 1888.

It seems to have been owing to secondary or induced electric surgings in a horizontal bar of metal totally disconnected from anything; not pretending to lead toward earth, and being some little distance below a stretch of lightning conductor not offering itself as an object to be struck. On all the old views it was utterly insignificant. However, as a matter of fact, although not struck, although it did not even (probably) receive a side flash, yet the induced surgings set up in it, induced by Maxwell and Heaviside's electro-magnetic waves, were so violent as to ignite some gas and cause a small fire.

This occurrence, and certain sparkings in the wall paper of the Royal Institution (see *Electrician* on "Nature," March, 1889), are plain and straightforward intimations that the old views on the subject of electric conduction are hopelessly, and absurdly, and dangerously inadequate. It is time that the prophets of that old superstition were slaughtered by the brook Kedron.

Practical Questions.

50. There remains to consider what is to be the practical outcome of all this. What improvements in the erection and testing of lightning conductors are possible. This is a matter well worthy of discussion, and eminently suited to it. It is a matter on which I have not the slightest wish to be dogmatic; and if I make a few apparently definite assertions it is only by way of expressing such judgment as I have been able to form at present, and they are to be taken as intended more by way of suggestion and question than anything else.

With this proviso I should be disposed to make some such statements as the following:—

51. All parts of a lightning conductor, from points to roots, should be of one and the same metal, to avoid voltaic action.

52. Joints should be avoided when possible, and should be made substantially when necessary. Allowance for expansion and contraction must not be forgotten.

53. Sharp bends, and corners and curves and roundabout paths to earth, should be avoided as far as possible.

54. The use of copper for lightning conductors is a needless extravagance.

55. Iron has advantages over every other metal.

56. The shape of cross-section is but little matter. Flat ribbon has a slight advantage over round rod, but not enough to override questions of convenience.

57. Liability to be deflagrated by a powerful flash determines the minimum allowance for size of cross-section. No consideration of conductivity and greater ease of path has the least weight in this connection.

58. It is hopeless to pretend to be able to make the lightning conductor so much the easiest path that all others are protected. all possible paths will share the discharge between them, and a lot of apparently impossible ones.

59. A good and deep earth should in general be provided, independent of water and gas pipes.

60. If the conductor at any part of its course goes near water or gas pipes, it is best to connect it to them.

61. If the place to be protected has water or gas pipes inside it, the conductor should be connected to their mains underground.

62. At all places where water and gas pipes come near each other, and, in general, wherever one metal ramification approaches another, it is best to connect them metallically.

63. The neighbourhood of small-bore fusible gas pipes should be avoided in erecting a lightning conductor.

64. Into powder magazines and such like places no gas or water pipes should be permitted to enter, unless the whole building is made of metal, and they are elaborately connected to it at the point where they enter.

65. It is not wise to erect very tall pointed rods above the roof of a building.

66. A number of points all along the ridge of a roof is better than only a few.

67. Any part of a building is liable to be struck, and to make quite secure, every prominent part of the outside should have a rod running along it.

68. Insulated as well as earth-connected bodies are liable to spit off sparks.

69. No complete security can be attained unless the whole building be metal-covered.

70. In ordinary houses it may be well to try and insulate the lightning conductor from the walls, so as to lessen the chance of side flash to metal stoves and things inside.

71. In chimneys it may be well to use insulators to protect the bricks from concussion.

72. The cheapest way of protecting an ordinary house is to run common galvanised iron telegraph wire up all the corners along all the ridges and eaves, and over all the chimneys, taking them down to the earth in several places, and at each place burying a load of coke. Rain-water spouts and other outside metal, if all well connected together, may likewise be utilised.

73. Connecting a lead roof or other such expanse with a lightning conductor is not an unmixed good, for it virtually increases the dangerous proximity of the lightning conductor, and may inadvertently bring it near to many objects which else might have escaped.

74. One of the most difficult things is to know what to connect and what to avoid.

75. The orthodox rule, "Connect all pieces of metal to the lightning conductor," requires modification thus:—Connect all pieces of metal to each other and to the earth, but not to the lightning conductor.

76. It may be always reckoned safe to earth things independently. It is often not safe to connect them to the lightning conductor: *e.g.*, an inside lining of a chimney should be well earthed, but should not be used as lightning conductor nor connected with it. The same with rain-water pipes and gutters. The same also, probably, with lead roofs.

77. In connecting pieces of metal to each other, if they happen to form a nearly closed circuit, the circuit should be metallically completed.

78. Over the top of tall chimneys it is well to take a loop or arch of the lightning conductor, made of any stout and durable metal.

79. Lightning conductors should be always outside, and easily visible.

80. A conductor detached from the building to be protected is safer than one in close contact with it.

81. An outer cage surrounding the building, with sky points and earth roots, and an inner cage on the building, with independent earth terminals only, is the safest plan.

82. If under these circumstances there be no gas pipes nor much ramifying metal work inside the building, and no metal at all going near either cage, the interior may be considered perfectly safe.

83. The inner cage may often be conveniently made of continuous sheet iron. The outer cage need not then be at all small-meshed; in fact, it need be little more than a dozen vertical conductors.

84. The resistance of an earth may be tested in the customary way to guard against actual breaches of contact by rust or workmen; but no overweening confidence must be felt, even though the resistance turn out the thousandth of an ohm or less.

85. A Wimshurst machine and couple of Leyden jars afford a convenient mode of testing a conductor for flagrant defects. The testing should be done in the dusk or in moonlight, so that there may be light enough to work by and yet sparks be visible.

86. Telephones are the handiest things to detect electric surgings in conductors inside the house while discharges are being made to the conductor. But vacuum tubes, gas leaks, Abel's fuses, &c., can also be employed.

87. Another mode of testing can be carried out on an insulated rod, with an induction coil and spark gap after the manner of a great Hertz oscillator. This is probably the most searching plan. Sparks will then be probably obtained from all the gas brackets, water taps, and picture rails in the house.

88. Telegraph stations, and houses supplied with electricity from overhead wires, should have an efficient lightning protector at the place where the wires enter the house.

89. When a number of houses are wired up together for lighting, even by underground wires, it may be well to disconnect them by means of intervening lightning protectors on the principle of fire-proof doors.

90. A central lighting station, having a tall chimney connected to its boilers and dynamos, should be, by a lightning protector, disconnected from the leads which carry the current from it; because a small fraction of a stroke getting into the leads might destroy a number of lamps, especially if they were already working at something like their full power.

91. Telephone arrangements, and any length of close-packed insulated wires (even underground) should be protected by lightning protectors, else the insulation is apt to be sparked through and spoiled.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888.

924. "Improvements in electrical measuring and recording apparatus." J. G. LORRAIN. Dated January 20. 1s. 6d. The principle of the invention lies in the alteration of position of a vessel through alteration of the specific gravity of its fluid contents, such alteration of specific gravity being brought about by alteration of temperature caused by the passage of the electricity to be measured, or a portion thereof, through a conductor placed in the said vessel. The motion of this vessel may be communicated to any convenient form of mechanical counter, or it may call into action what is known as an electric counter. The claims are 14 in number.

2130. "Improvements relating to electric telegraphs." A. MUIRHEAD. Dated February 11. 8d. Relates to duplex electric telegraphs, and its main object is to diminish the cost of the apparatus required for working long submarine cables upon systems such as that known as the Muirhead "double-block" system. The inventor has discovered that a sufficiently near balance can be obtained to permit efficient duplex working, with an artificial line of much less capacity than the cable. For this purpose he increases the resistance of the artificial line in such a manner that, although the capacity thereof is less than that of the cable, the product of the resistance and the capacity of the artificial line is equal to the product of the resistance and capacity of the cable. The claims are 3 in number.

3328. "Improvements in electric contact makers and commutators." C. L. DAVIES. Dated March 3. 8d. Claims:—1. The combination with the key of a movable pin operated thereby so that in the ordinary working of the key, opening and closing principal contacts, other contacts are simultaneously controlled, substantially as described. 2. Electric contact makers and commutators substantially as described.

3672. "Means or appliances for use in connection with electric circuits or water or gas supplies or the like to enable a supply of electricity for lighting or other purpose, or a supply of water or gas or the like to be obtained on the deposit of an equivalent therefor in the shape of prepayment or otherwise." H. EDMUNDS. Dated March 9. 8d. The object of the invention is more particularly to provide means in connection with electric lighting circuits whereby on prepayment being made for any predetermined period of use of the electric current for lighting and only on such prepayment having been made the light can be obtained for the said period. The claims are 8 in number.

4568. "Improvements in or relating to conductors for electrical and acoustic purposes." S. WILLIAMS. Dated March 26. 6d. The inventor takes ordinary copper or other wire of any suitable gauge, but preferably thinner than No. 10 B.W.G., and by any approved process serves it with a coating of rubber, gutta percha or other similar suitable material of a homogeneous texture. He then causes the wire thus insulated to receive a deposit of any of the vehicles known in electro metallurgy for rendering non-metallic surfaces electro-conductive that is susceptible of being coated or plated with metal by any approved metallurgic process. For such a vehicle may be used black lead, or black lead mixed with say about a third of its weight of finest white bronze powder, and the insulated wire so prepared is then coated with a deposit or skin of copper or other metal, either by simple immersion or other process known in electro metallurgy suitable for the purpose indicated. The conductor in its complete and finished form fur-

nishing for electrical purposes a double circuit in the shape and space of what practically, for construction and other purposes, amounts to one wire. He also takes a thin flat strip of suitable metal, and by passing it between two or more grooved wheels, in which a "former" to preserve the centre hollow is arranged to work, he thus produces a thin flexible metal tube of dimensions and other characteristics of ordinary telegraph wire. He then further deposits on the outer surface a coating of metal, by the usual electro metallurgical processes, in order to render the tubing air tight in the seam. This hollow wire he intends to be applicable for use as speaking tubes, and for some of the purposes for which telephone exchanges are used, as it can be dealt with under the general conditions attaching to ordinary telegraph wire. The claims are 4 in number.

4764. "Improvements in portable galvanic and electro magnetic batteries for medical purposes." A. L. FRY. Dated March 28. 8d. The inventor combines plates of any suitable metals which, when in contact with the skin or with a suitable exciting medium, will set up a galvanic action, and into a hole or opening or around such plates he inserts or applys either a permanent magnet or a bar of soft iron having an insulated or covered wire wound around it, one end of the wire being placed in contact with the copper and the other with the zinc plate when those metals are used. The claims are 2 in number.

5191. "Improvements in storage batteries." H. EDMUNDS. Dated April 7. 6d. Claims:—1. The employment in secondary batteries of a layer of insulating material poured on to the electrolyte which will set solid and form a protecting layer against injury to the lead or other couples, and may allow of a space between the electrolyte and under surface of the insulator. 2. The employment of a covering of an insulating substance poured on to the surface of the electrolyte or depolariser of an electric battery effected in the manner of and for the purposes described.

5196. "Improved means for conducting and collecting currents in electric rail or tramway systems." M. HOLROYD SMITH. Dated April 7. 1s. 1d. Consists in the arrangement and combination of parts with reference to what are known as overhead systems, although the invention may be adapted for underground or side systems. The claims are 6 in number.

5201. "Improvements in apparatus for effecting by introduction of a coin production of electric light for a certain time." D. H. DAVIES and J. M. TOURTEL. Dated April 7. 11d. Relates to improvements in the apparatus described in Provisional Specification, No. 8206, of 1887. The claims are 4 in number.

5452. "An improved fusible device for protecting electric circuits." J. G. S. CUNNINGTON. Dated April 12. 8d. A fusible conductor is mounted on a carrier of insulating material, and is in electric contact preferably by means of solder with contact pieces which are fixed to the said carrier, and are preferably made of copper presenting a considerable surface. The two portions of the circuit to be joined by the device are provided with contact pieces preferably constituted by clips held in a slot in a suitable mounting, so that they grasp and bear on the aforesaid contacts on the carrier, and so that the carrier can be readily slidden into place, and readily removed to complete the circuit. The carrier is provided with a projecting portion to be grasped by the person using it. The contacts in the mounting, and the slot in which they are situated, correspond in size only with the contact pieces of a fusible conductor fitted for the particular circuit, so that only a fusible conductor fitted for the circuit can be used. The claims are 2 in number.

5786. "Improvements in clips or holders, applicable for use in connection with telephones and other instruments, whereby writing paper for recording messages received, or books and the like, can be firmly held in place while messages are received or transmitted." G. CASHEL. Dated April 18. 8d. The inventor provides a metal clamp, preferably of flat section, having its ends bent into the form of a hook or other suitable shape. The clamp is made in two parts, so that the ends can be adjusted as regards their distance apart. This can be effected by means of a screw attached to one of the parts, which passes through a slot in the other part, the two parts being tightened firmly together by a nipple or milled nut. To the said clamp is attached (by means of eyes or in other convenient manner) a spring clip, preferably made of wire, and having one or more turns or coils, so that while one end can readily be raised, it will always spring back, and lock or hold the paper, &c., firmly in position. To facilitate the raising of the spring clip, it is provided with a loop, bend, or projection, which serves as a lifting handle. The claims are 4 in number.

5790. "Improvements in and relating to the preparation of non-metallic porous surfaces for electro metallurgic deposits." H. STEINACH. Dated April 18. 6d. Claims:—1. In the preparation of non-metallic porous surfaces for electro metallurgic deposits, the treatment of the same with tar purified from ammonia liquor acids, ethers and bases, or from the greater part thereof. 2. In the treatment of non-metallic porous surfaces with purified tar for the purpose set forth, the combination with or addition to the tar of paraffin substantially as and for the purpose described. 3. The described process of treating gas tar for the purpose set forth, consisting in agitating with dilute sulphuric acid washing with water agitating with dilute soda lye or equivalent alcaline liquor, and again washing in water. 4. The removal of the superfluous coating from objects prepared for electro metallurgic deposits by means of a jet of hot air or steam or other heated vapour or spray substantially in the manner described.

5898. "Improvements connected with telegraph apparatus for communicating between one part of a navigable vessel and another or others." W. CHADBURN. Dated April 20. 11d. Relates to that type of apparatus used on board navigable vessels for communicating between one part of the vessel and another, or others, in which the orders, conditions, or notifications are transmitted from one instrument to another by electricity. The claims are 6 in number.

5899. "Improvements connected with ships' engine-room telegraphs." W. CHADBURN. Dated April 20. 8d. Has for its object to effect certain improvements in that class of mechanical, pneumatic, or electric telegraphs, which are used in navigable vessels, and which are known as revolution telegraphs, and are used to transmit orders to the engineer to run the engines at certain speeds. The claims are 11 in number.

6214. "Improvements in laying underground electric conductors." C. W. FARQUHAR. Dated April 26. 8d. Claims:—1. The described system of laying underground electric conductors, consisting in laying the conductors in pipes that are formed with their upper part removable, the wires being laid into notches in or threaded through holes in such bearers, and the bearers being arched or hollowed on their underside to permit water to drain off and pass away at suitable intervals. 2. The combination of the socketed stoneware pipes divided longitudinally so that their upper part is removable, arched bearers placed therein at intervals, and electric conductors supported in notches or threaded through holes in the arched bearings, substantially as described.

6322. "Improvements in galvanic batteries." P. R. DE FAUCHEUX D'HUMY. Dated April 28. 8d. The object of the invention is to produce a compact and convenient form of battery, chiefly for lighting purposes, consisting of many cells which are capable of being readily filled with the exciting liquid and emptied, and into, and from which the metal electrodes can be easily introduced and withdrawn as required, in order to put the battery into or out of action. The claims are 11 in number.

7355. "An improvement in field telegraph and other similar conductors." R. VON FISCHER TREUENFELD. Dated May 17. 4d. Claim:—Constructing a strong but light electrical conductor by arranging fine wires in several layers twisted or laid substantially as and for the purpose set forth.

CORRESPONDENCE.

Pocket-Book of Electrical Rules and Tables.

In your review last week of the sixth edition of of this Pocket-Book you complain that "several formulæ, &c., which relate to the same subject are scattered about the book instead of being grouped together." Also, that "the index needs revising, as it is incorrect and hardly full enough in several places."

A very great deal of time and money has been spent in endeavouring to keep formulæ, &c., relating to any particular subject as much together as possible, and we have had recourse, as you will have observed, to interposing pages with suffixes *a*, *b*, *c*, &c., to the number of 126 pages more than the 498 indicated by the last page in the book.

If we can still further pull similar matter together we shall feel very much obliged to you if you will kindly point out where? It must be remembered, however, that as the whole book was stereotyped from the first edition the alteration of letters and formulæ, or their transposition, is no easy or cheap matter. I was under the impression that the index was one of the most complete and exact to be found in any book. Certainly 17½ pages seems a good deal to be devoted to such a purpose, but here again we shall be grateful for definite and exact information as to where the index is wrong or incomplete, as our main desire is that the book may be accurate and thoroughly useful.

Andrew Jamieson.

May 7th, 1889.

Theatre Lighting.

In your leading article on lighting of theatres in this week's review we note that you say that Drury Lane has the electric light on the stage but not in the front. As a matter of fact there is no electric light

whatever at Drury Lane, although Mr. Augustus Harris has contemplated doing so several times.

You omitted to mention in your article that the Lyric Theatre is lighted up entirely, no gas being used in the Theatre.

Rashleigh Phipps & Dawson.

May 4th, 1889.

Uppenborn's History of the Transformer.

It seems to be difficult to find agreement as to the history of transformers between the various authors and lecturers on the transformer systems of distribution.

Uppenborn, in his little pamphlet just translated and published, gives a history of the transformer, which fits in very nicely with his view, that the invention of the non-polar transformer was due to Messrs. Ziperknowski, Deri and Blathy.

He contends that the original Faraday ring is not similar to the non-polar transformers now in use, arguing that there will be poles formed at the ends of the primary coil, and that as the two coils were almost similar in length and section, it could transform either from low to high, or from high to low pressure, therefore it was not a transformer. This last argument is not founded on facts, as a reference to the *Phil. Trans.*, 1831, proves that the primary wire was 70 feet long, and secondary 60 feet, so that it would be a transformer with a ratio of six-sevenths.

There certainly would be some polarity in the ring at the ends of the coils, but these poles would be due to the different phases of the two currents more than to the difference in position of the two coils.

All mention of Varley's non-polar transformer, patented in 1856, is entirely omitted. In this transformer the two coils are on one core, and this core forms a complete magnetic circuit without poles, a core, moreover, in which lamination is almost perfect.

It must be admitted that the advantages of the closed magnetic circuit, and the division of the core in induction apparatus, were known to Varley in 1856. In his patent he shows clearly how to use both, so that inasmuch as the core or iron portion of a transformer is concerned, there are no essential improvements in the later transformers now in use.

The early users of transformers, Jablochkoff and Gaulard, naturally employed the form of transformers most commonly made, namely, the Rhumkorff pattern, with little or no essential variation in construction. They did not evidently appreciate a closed magnetic circuit as of any value for their purposes, and they used them in a series circuit, the result being total failure to effect a distribution of current on a practicable scale.

Self-induction was known to exist in transformers, but none of the early users of them thought of taking any advantage of it in connection with their schemes until Hopkinson proposed to use self-induction coils as resistances for alternating currents. The self-induction and mutual induction between the two coils in a transformer were first pointed out as the cause of the failures to work transformers in series by the author of this note in his letters to this Journal, beginning in June, 1883. One discovery was necessary to show that transformers could be used for distribution by placing them in parallel connection, and that was, to ascertain whether the primary current in a transformer rises and falls in value proportionately as the secondary current rises and falls in value. I discovered that the primary current rose and fell proportionately as the secondary rose and fell in value, and that fact is abundantly proved by the letters referred to. This discovery led to the inevitable conclusion that the pressures at both pairs of terminals must be fairly constant. I also became thoroughly acquainted with the value of the counter E.M.F. due to self-induction, and the part that it played in regulating the rise and fall of the primary current, another fact abundantly dwelt upon in these 1883 letters of mine. These facts, on becoming known to me, made it perfectly clear that by using transformers in parallel they would be perfectly self-regulating, and I concisely stated my belief at the conclusion of the first letter.

That I used the word "prodigious" to qualify the conductors required for a parallel system of distribution at that time has been unfortunate if it led any one to suppose that I did not expect a saving in copper by the use of transformers.

I used the word then, as I would use it now, if applied to the mains proposed to supply, say, 1,000,000 100-volt lamps, with, say, 2,000 volts in the high-pressure mains. 1,000,000 lights were not a large number in 1883, but 2,000 volts was considered a somewhat large pressure, and a conductor 12 square inches in section was then something prodigious to contemplate at that date.

Uppenborn reads these letters, and states that I did not apprehend the physical facts concerned either in the failure or success of the transformer, and on page 59 says that I openly held the parallel system to be impracticable ! ! ! How these statements can be reconciled with my 1883 letters, and my advocating the use of transformers in parallel to make them beautifully self-regulating, is a question Herr Uppenborn alone can answer.

After demolishing the claims of Jablochkoff and Gaulard, the book winds up by awarding the credit of inventing the closed circuit transformer, and the parallel system of using it, to Messrs. Zipernowski, Deri, and Blathy.

I, for one, think they deserve more credit, and have done more for the perfection of the system and transformers than Jablochkoff and Gaulard ever did, and it cannot be doubted that in the future they will always retain an honourable position amongst those who have initiated the new and successful system ; but, at the same time, however little credit may be due to those patentees who came after the date of Zipernowski's patents in 1885, it is only fair to expect writers and lecturers to give credit where it is due to prior inventors in the same direction.

The history of transformers is not of much interest, generally speaking, were it not for the claims set up for inventors who did not invent anything which had the slightest effect in bringing about the present success of the "distribution by alternating currents and transformers," and whose object appears to be to reap the benefits of the past six or seven years' improvements made by others. Herr Uppenborn's history is worth reading only for the views it contains on claims of the various parties who are interested in the earlier patents ; but it requires correction in the particulars referred to in this letter.

Rankin Kennedy.

Alternating Current Motors.

We have pleasure in informing you that we have succeeded in constructing an alternating current electric motor of absolute practical perfection, which, especially in point of efficiency, is in no way inferior to the most perfect continuous current motor. The enclosure contains particulars of this motor and the experiments made with it, and we with pleasure place it at your disposal for publication in your esteemed journal.

Ganz & Co.,

Eisengiesserei und Maschinen-Fabriks-Actien-Gesellschaft in Ofen, Electrotechnische Abtheilung.

Per ZIPERNOWSKY.

Budapest, *April 10th*, 1889.

[The paper which we publish on another page is a translation of the MS. sent to us by Messrs Ganz and Co. There is nothing to be learned from the article or a drawing which accompanied it with regard to the construction of the motor, and this, we take it, is what our readers are most anxious to become acquainted with. At the same time we must tender our thanks to the eminent Budapest firm for informing us of the experiments.—EDS. ELEC. REV.]